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THE APPLICATION OF EFFICIENCY PRINCIPLES

BY
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PREFACE

The idea of this book occurred to me nearly five years ago, as a result of a conversation with Mr. Charles B. Going, of the *Engineering Magazine* (now *Industrial Management*) in which he expressed a wish that some one would tell how to apply efficiency principles, as a sort of a supplement to Harrington Emerson's statement of these principles in his book.

Since then have appeared Arnold's *Ford Methods and the Ford Shops* and Knoeppel's *Installing Efficiency Methods*, the latter based on a hypothetical but definite case.

Between Emerson's book on the one hand, and Arnold's and Knoeppel's publications on the other, the manager still fails to find exactly what he wants, because Emerson gives him an excellent statement of principles but very little about how to apply them, while very much of Arnold's and Knoeppel's specific cases will not fit his needs and he must reason from them back to fundamental principles, and from these principles work out his own methods.

It therefore seems to me that there is need for a book which should deal with application, rather than with a statement of principles; but which should give as general a treatment of application as can be made concrete and practical.

This book is an effort to meet this need.

I have taken Harrington Emerson's statement of the principles of efficiency and attempted to show how each of these principles can be practically applied. Wherever possible I have taken, from my own experience or the work of others, practical illustrations of the working of each principle not from any particular field but from any field that could furnish a definite example demonstrating its application. I have tried to analyze these applications back to their fundamental principles in such a manner that the reader can clearly see the relation between the principle and its applications.

My endeavor has been to strike a happy mean between the

theoretical consideration of efficiency on the one hand and the specific description of efficiency application on the other so that the reader will, I hope, find its statement of underlying theory and illustrating application so clear that he will readily grasp the possibilities of like application to his own problems.

Our knowledge of any subject of the magnitude of efficiency is necessarily the result of the labors of many workers. In preparing this book I have freely consulted many other writers on the subject. Where I have drawn from them, I have done so, if possible, in the form of direct quotation with acknowledgment. My only adequate acknowledgment to Harrington Emerson is that of a pupil to a teacher. During three years in his organization, I made every effort to learn from him. My thanks are also due to Naval Constructor R. M. Watt, U. S. Navy, Industrial Manager of the Norfolk Navy Yard, and to Mr. Charles B. Going, for kindly reading and criticising the manuscript, and for valuable suggestions.

George H. Shepard.

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Chapter I

THE PRINCIPLES

1.

EFFICIENCY depends upon the application of only a few principles; and the analysis of any example of high efficiency will reveal all of them in use. The plant of the Ford Motor Company is one of the best known examples.

Referring to its Commutator Department, Arnold in "Ford Methods and the Ford Shops" says, "The commutator job is regarded by the Ford shop heads as being in as nearly satisfactory condition as any department of the entire plant, and the low labor costs therein reached, fully warrant the minutely detailed and profusely illustrated story here printed."

As Arnold summarizes the causes of the high efficiency of the Commutator Department, I have selected his statement for analysis into fundamental principles, under one all-embracing principle, Higher Common Sense.

Higher Common Sense

HOW FORD SHOPS MAKE A COMMUTATOR IN 16 MINUTES AND 27 SECONDS OF ONE MAN'S TIME.

(1) By minutely dividing labor operations. **Adapted Conditions**

Many of the operations are the work of automatic tools.

Correct Methods
Instruction

Minute division of operations is effective in labor-cost reducing in two ways; first by making the workman extremely skillful, so that he does his part with no needless motions, and secondly by training him to perform his unvaried operation with the least possible expenditure of will-power, and hence with the least brain fatigue.

Fair Deal
Adapted Conditions
Discipline
Correct Methods

(2) The work hours are short, 4 hours at a stretch only, so that workmen in good form can, and do, stand in their tracks, working with the regular production of an automatic machine.

Planning

(3) Work-slides, successive-operation men and successive-operation tools and appliances, are so placed that one man drops a piece when his part is done, either where it is ready to the next man's hand or where the gravity work-slide will carry the piece to the next man's ready reach.

Adapted Conditions

(4) Placing the case foundry on the machine floor, close to the machine tools, is a very great time saver. Not only is the rough-case supply made certain, but the castings are perfectly moulded and come to the finishers in best possible form, with least possible thought, travel, and labor, both of the head and the workmen.

Planning

(5) All operations requiring heat, melting, annealing, hardening and tempering, are performed in furnaces so located, and so grouped where more than one heating is needful, as to save all possible time expenditure.

Adapted Conditions
Correct Methods

(6) While the machine tools used are all regular commercial productions, the fixtures used with them are most elaborate, carefully designed to save movements as far as may be, and are well made, so that the workman need exercise no care or scrutiny in using them.

(7) In three instances the special tools and fixtures used are unusual; the two turret machines which produce T-671 have been so

ingeniously changed as to produce more than double the work that could be turned out by ordinary handling of a turret machine.

(8) Constant supervision of workmen, constant work inspection, and constant watching of tool-cuts by the two tool-setters, give skilled overlooking to the work of every man on the commutator job. Many of the machine hands, though not regular machinists, are highly skilled and grind and set their own tools. Every workman is perfectly aware that he is under constant observation, and that his supervisors know his work and his pace perfectly, and that he will be admonished if he falls below the fast pace of the department.

Discipline
Organization
Instruction

Selected Personnel

Records
Discipline

(9) An automatic drill chuck, the "Gronkvist" can be handled more rapidly than anything ever seen previously by me, and saves much time.

Standards
Adapted Conditions

(10) The workmen are suitable for the performance of their operations, and for their environment and working conditions. They are docile, and yet the physiologist will seek in vain for weak chins and narrow heads in the portraits of these workers who are, without exception, mentally capable of concentration and determined effort, having well defined firm chins, wide jaws and wide heads.

Selected Personnel

After reading the foregoing summary of Ford labor-cost reducing elements, the Commutator Department head asserted its correctness, but added as follows:

"I depend largely on my tool-setters for my production. The tool-setters know exactly what I want, and as long as the tool-setters have plenty of newly-sharpened tools on hand, all ready to go into the machines as soon as tools in use show loss of smooth-cutting edge, I have no trouble in keeping my production up to the 1750 per 8 hours' mark. But if there is even a very small delay in replacing a cutting tool, which does not work exactly right, trouble begins."

Organization
Adapted Conditions

Planning

Standards

Fair Deal Efficiency Reward Ideals

Undoubtedly this post-script is of first importance in this 16 minutes and 27 seconds achievement.

Beside the causes stated by Arnold, there are, of course, the well-known Ford high wages, bonus and general welfare work.

2. Separating out the principles, they appear as follows:

HIGHER COMMON SENSE

- Adapted Conditions
- Correct Methods
- Instruction
- Fair Deal
- Discipline
- Planning
- Organization
- Selected Personnel
- Records
- Standards
- Efficiency Reward
- Ideals

3. For clearness and convenience of application it is desirable to restate the principles in slightly different form.

Soon after I took up efficiency work, it became apparent to me that some few of the principles, like the primary colors of the spectrum, potentially contained all the rest; but I could not determine for some time which these were. In January, 1913, I was sent to the Pittsburgh and Lake Erie railroad to collect data for the series of articles on that road which Harrington Emerson was then writing for *The Engineering Magazine.* I found there a very high efficiency; I

also found that only three of the principles had been consciously recognized. There was a very remarkable personnel, scientifically organized, and pursuing correct ideals. Personnel, Organization, and Ideals had been strongly applied; and I found that a selected personnel, pursuing correct ideals through scientific organization, had of itself applied all the other principles, for all of the principles were in use.

These three, therefore, are the primary principles. All the colors of the spectrum in a perfect blend make white. Similarly, Personnel, Organization, and Ideals result in the application of all the principles; and we then get the effect of the great all-inclusive principle, Higher Common Sense.

4. It is to be noted in paragraph 1 of Arnold's statement how closely Correct Methods and Instruction combine with each other. This is typical. Only that which is earnestly studied can be well done. Only that which is practiced can be thoroughly learned. Therefore, Instruction and Correct Methods are inseparable, and I have bracketed them together in the statement which follows.

No plan is of any value unless it is continually followed up and enforced. From analogy with railroad practice this process has been called Despatching. It needs to be emphasized more strongly than would appear from the example of the Ford Commutator Department, and so I have added it to the principle of Planning.

We always desire to adapt conditions to the work to be done, but this is not always possible. For example, we can not so adapt the conditions at sea as to make commercially profitable the speed of the railway, and we are forced to the slower transportation by ship.

Adaptation must therefore work both ways; for if we cannot adapt the conditions to the work, we must adapt the work to the conditions.

5. The principles can then be restated as follows:

ALL INCLUSIVE	PRIMARY	SECONDARY
		Adaptation of Conditions and Work to Each Other
	Ideals	Correct Methods Instruction
HIGHER COMMON SENSE	Personnel	Fair Deal Discipline
	Organization	Planning and Despatching Records Standards Efficiency Reward

The above statement is somewhat modified from that of Harrington Emerson, who first stated twelve definite principles as the fundamental causes of all efficiency.[1] This was an astounding feat of analysis and a service comparable to analyzing all matter into a few chemical elements; a feat and service for which he has not yet received the credit that is justly due him.

6. While all of the principles have a moral aspect, this is so pre-eminently true of certain of them that they may be called the ethical principles. These are Ideals, Fair Deal, Discipline, and Efficiency Reward.

Emerson has rendered another great service in insisting inflexibly, and regardless of personal interest, upon the ethical principles. He has well pointed out that in the voyage of the Titanic all of the ethical principles except Discipline were violated; and that

[1] "Twelve Principles of Efficiency," by Harrington Emerson; The Engineering Magazine Co.

the loss of the ship resulted though all of the other principles were applied.

The severest criticisms of efficiency arise from ignorance of the ethical principles. One often reads statements that although the immediate economic effects may be valuable, the moral effects are always harmful, and the ultimate economic effects disastrous. If the critic states his reasons, analysis will reveal complete ignorance of the ethical principles.

7. In the analysis of the causes of efficiency of the commutator department of the Ford plant, the prominence of Adapted Conditions is noticeable. This results from two underlying conditions of the Ford business—making a single article and making it in large quantities. In other work in which these conditions do not exist, Adaptation, though it would still apply, might be of much less importance and might be impossible of anything like such extensive use.

Every problem has its own peculiarities which result in wide differences of methods and devices. Hence, a mere statement that such and such things have been done in some plant is in itself of very little value. One who devotes his efforts to searching such records for things which he himself can use, is apt to be like the stutterer who practiced "Pickled peppers" until he could say it perfectly; but, as he complained, "It s-s-so s-s-eld-d-dom oc-c-c-c-urs in c-c-c-conversation."

On the other hand, every one of the principles listed from the above analysis applies to every management problem, even if the specific case be as different from the Ford plant as that of a hospital, a school, or a church.

8. In an effort one time to increase the efficiency of a gang of workmen, I had adapted conditions, had de-

termined standards, had planned and despatched their work, had installed records, and had applied efficiency reward by offering a bonus above their previous time rate for any increase in their efficiency. At this point I found progress blocked by a violation of the principle of Ideals by the boss, who held that limitation of production was necessary for his protection. To apply the apparently obvious principle of Instruction and teach the economic fallacy of limitation of production would, with most workmen, be useless. Instead, the principle of the Fair Deal was applied. Occasionally the gang would make a good enough efficiency to earn a little bonus. Just as soon as they found that they had done this, they would drop to a very low efficiency. The boss was afraid, in fact, to make a good efficiency, because as he told me plainly, he believed that as soon as he did so, the bonus would be withdrawn and he would be driven to make the same efficiency on his bare time rate on pain of losing his job. However, the bonus attracted the gang; and after a while they would slowly come up to a good efficiency, only to slump again as soon as they found that they had earned bonus. Their conduct was like that of wild animals approaching food while fearing a trap.

Every time the gang earned bonus it was paid them, and none of their standards was made more severe. On the contrary, a considerable number of standards that were found to be too severe were made easier. After experiencing this kind of treatment for nearly three months, the gang acquired confidence, and thereafter worked continuously at a high efficiency. Continuous practice of the Fair Deal won in the end.

An alternative course would have been to have ap-

plied the principles of Discipline and Personnel, and to have replaced the original gang by men who would have been more willing to produce results; but they were to some extent justified in their suspicions by the fact that the management had at former times yielded to the temptation to cut piece rates on which it considered that excessive earnings had been made. Hence, the Fair Deal required that these men should be allowed to satisfy themselves of our good faith in their own way.

9. As in the above case, every one of the principles is continually mixing up with all the rest; so that while one is earnestly seeking to apply one, he may at any time be confronted by the need for the application of others.

Hence, the only guide through the mazes of efficiency work is a knowledge of all the principles.

To ask the efficiency engineer for a definite statement of procedure is like asking the navigator what course he steers at sea, and as little admits of a general answer. The navigator can, indeed, lay a definite course for any voyage, but he does so by applying the principles of navigation. So the efficiency engineer can define procedure in any situation, but he does so by applying the principles of efficiency.

Also, while a study of any experience in efficiency usually yields but little in the way of methods that can be directly applied to any other case, the analysis of any such experience into the application of fundamental principles, as shown in the case of the Ford commutator, will always yield something of value in the shape of deeper and more thorough knowledge of the principles themselves, and of greater skill in their application to any case that may arise.

10. Also, as appears in the example cited in paragraph 8, the principle which comes first to mind as applicable is not always the one that will produce results. The only way that errors of this kind can be avoided is by the continual study of one's own experiences and those of others in the light of the principles. The words of Dr. Schurman, "Practice without theory is blind, and theory without practice is empty," apply strongly to all efficiency work.

11. Because of the interplay of the principles with one another, it is impossible even to discuss any one of them without continually bringing in the others. Hence it is necessary, before discussing any principle in detail, to give a general statement of all of them.

On the other hand, any general analysis, either of theory or practice, must proceed in the main along the line of one principle at a time. These chapters, therefore, resemble in structure Harrington Emerson's work "The Principles of Efficiency" in that they discuss each principle in turn; but the point of view is different. Emerson's Ideal was the explanation and propagation of the principles, while this volume assumes that the principles are understood and accepted, and undertakes to tell how to apply them.

The efficiency engineer is always steering between Scylla and Charybdis. Adherence to one principle only, to the neglect of others, is sure to run him into trouble one way or the other; but safety and success lie in the simultaneous practice of all.

CHAPTER II

PRELIMINARIES. TROUBLES

12.

A FOREMAN, who was taking me through a plant where I was investigating the possibilities of increasing efficiency, pointed out to me a piece worker, and remarked, "I have a hard time to keep that fellow from earning two dollars and a half a day." I replied, "It would be altogether better if he did earn two and a half a day wouldn't it?" "Oh, no," replied the foreman. "If he did that, the time clerk would come around and say, 'Gee! That's a lot of money, isn't it?' Then the office would cut the piece rate on that work, and the rest of the men couldn't earn enough and would quit. So, in order to keep from losing the rest of my men, I have to watch him and bother him enough to keep him from earning two and a half a day. If you get a man who *will* earn too much in spite of all you can do, you just *have* to fire him."

Considering the above incident, we see at once a violation of the principles of—

The Fair Deal,
Efficiency Reward,
Discipline, and
Common Sense.

Following the line of investigation thus suggested, I found that the management made a regular practice of watching the earnings of its piece workers, and of cutting a rate as soon as any one earned more on it than was considered the proper time rate for his class of labor.

In consequence of this, the False Ideal of limitation of production was so general through the plant that superintendents and foremen told their men not to do too much. In fact, due to this cause, production was about thirty per cent below what it might have been.

It is evident that the root of the whole trouble was the violation of the Fair Deal by the management; but the application of the Fair Deal was not the only step necessary for correction. Back of that lay the fact that there were no proper Standards. Having no standards the management had tried to set its piece rates by guess, and then to correct errors by cutting any rate that appeared to result in excessive earnings. This practice is very common, and always results in limitation of production by the workers who, realizing that they will be allowed to earn only so much, determine to get it as easily as possible.

The necessary steps were to determine standards scientifically; then to apply the Fair Deal by sticking to them, and Efficiency Reward by paying for good efficiency as determined by comparison with them.

13. Every violation of a principle of efficiency makes trouble somewhere; hence, the troubles in a plant are its symptoms of inefficiency and, therefore, of first interest to the efficiency doctor. Our bodies are so made that the least member that is in trouble can apply the principle of Records by sending in a sharp and insistent report in the form of *pain,* which meets with

instant and most sympathetic response from the intelligence in control. One of the objects of efficiency work is to give an industrial plant a nervous system; but, in the present general lack of it, pains and aches among the minor members may never be recognized by the head of the business until the annual balance is struck, and perhaps not then.

The minor executives, however, the foremen, subforemen, and straw bosses, feel such troubles very keenly. On account of their burden of responsibility they feel them even more keenly than do the direct workers. Consequently, it is at this point in the organization that the troubles, the symptoms of inefficiency, come to the surface.

Any concern that wants to know its own symptoms will learn a lot about them by getting from every one of its minor executives a frank statement of his troubles. Then, to diagnose, it has only to analyze these troubles into violations of the principles of efficiency, as I have done in the case cited in Article 12. Further, the remedy is to practice those principles which are found to be violated.

14. One exception to the above is to be noted. Most foremen and their assistants have never seen good Planning and Despatching. Therefore they are not conscious of the lack of them, and they generally have to be questioned in some detail to bring out the facts. I usually ask a foreman, "How do you plan your work?" Even this often fails to bring out the desired information, and I then have to resort to a line of questioning somewhat like the following—

What is that man over there going to do next?

How do you know he will do that next?

Why are you going to give him that job next?

How soon will he be ready for his next job?

How do you know he will be ready then?

Are the materials and tools ready for the job? If not, when will they be ready?

How do you know they will be ready in time?

I have found two foremen who proved to be planning and despatching their departments very efficiently in their heads, and carrying in their minds the whole layout of work in prospect; so I do not consider the absence of the standard apparatus of planning and despatching as sufficient evidence that it is not being done.

15. When you go to consult a doctor, usually he listens first to your own statement of your symptoms, then he orders off all clothes that interfere with what he intends to do next; and finally he goes over you with his stethoscope, his clinical thermometer, and perhaps with his X-ray machine.

The investigation of the minor executives' statements of their troubles corresponds to hearing the patient's statement of his symptoms. It is next necessary for the efficiency doctor to make his own investigation with all the skill that he possesses. A full knowledge of all the principles of efficiency shows the investigator where and how to look for violations of them and for failure to apply them; then, in order to prescribe the necessary remedies, he must know how to apply the principles. The succeeding chapters, therefore, take up the application of every principle in turn.

Chapter III

HIGHER COMMON SENSE

16.

AT any stage of betterment work as soon as a point of immediate attack has been selected its problems become the subject for the application of the principle of Higher Common Sense. The first operation necessary is that of the analysis of these problems by the principles of efficiency.

It may be necessary at any stage of betterment work (and it is practically always necessary at the beginning of one's experience in it) to examine formally the existing conditions by comparison with every one of the principles of efficiency: to ask (one's self, at least)—

How does this accord with higher common sense?
What are the ideals?
Is the personnel suitable?
What is the organization?
Are the conditions and work adapted to each other?
Are the methods correct?
Has the personnel been instructed?
Is there a fair deal?
Is there discipline?

Is the work planned and despatched?
Are there proper records?
Are there correct and adequate standards?
Is efficiency rewarded?

The difficulty of answering any one of these questions may necessitate the acquiring of further information. The best, quickest, and least expensive means is the one to use for the purpose. In industry that means is so commonly the time study that an example of one for this purpose is given in Table 12. (See Article 202.)

Of course, as one becomes skilled, such analyses by the fundamental principles become more and more instantaneous and sub-conscious; just as during the process of learning to read, the first slow process of spelling out every word letter by letter gradually disappears into the rapid recognition of each word as a whole, in which there is no conscious thought of the letters.

17. Nevertheless, analysis remains at all times fundamental in the application of the principle of Common Sense. A problem as a whole may appear complex beyond solution, but as it is separated into its elements, many of them are found to be familiar. The most usual case of this to the efficiency worker occurs in the time-motion study, in which an operation strange and new to him, and as a whole impossible for him to judge, is found to be composed of elementary movements whose efficiency he can gauge with approximate accuracy.

As soon as analysis has revealed the elements, attention can be focussed upon those which present difficulties by reason of their unfamiliarity. In dealing with these, the principle of Organization offers great

help through competent counsel. (See Articles 58 and 59.)

18. After analysis, and an adequate consideration of the elements revealed by it, comes synthesis. Analysis followed by synthesis often occurs in time-study work in which operations are analyzed into their elements, the time for each element is determined, and then these elementary operations and times are synthesized into formulas for the standard time on the complex operations for a wide range of cases. Examples of this are given in Tables 8 and 10, and in Articles 188, 189, and 191.

Another frequent case of synthesis is to take the elementary operations revealed by a time-motion study, eliminate unnecessary or waste operations, substitute efficient for inefficient elements, and, from the elements finally accepted, synthesize a correct method for the performance of the complex operation. This is illustrated in Table 6 and in Article 166.

Cost finding is another example of analysis and synthesis; as the cost is first analyzed into its elements, the values of these elements are determined, and then the elements are synthesized into the complete cost. Chapter XVI is devoted to the detailed explanation of this.

Evidently there may be any number of other uses for analysis and synthesis, and proficiency in both is essential for the successful performance of betterment work.

The result of any synthesis should itself be tested by all of the principles of efficiency, in a manner similar to that stated in Article 16 for analysis.

19. Knowledge, of course, is essential both to analysis and to synthesis. Common sense bids us not to try

to rediscover all previous knowledge, but to use the knowledge of the past as it is preserved for us in records. This recorded knowledge is the *theory* of the subject. It seems self-evident that we ought to value and use it; but one of the fundamental causes of our inefficiency is our scorn of theory. We tend, in fact, to a gross empiricism. We have only to keep on in that course to be absolutely dominated, in war and in peace, by the Germans, those four-eyed, high-browed, arch theorists of the world.

The word "higher" is added to the name of this principle in order to call attention to the need for knowledge of sound theory. If it were not for our tendency to undervalue such knowledge, this principle might as well be called "Common Sense."

20. The apparent reason for distrust of theory is a failure to realize its limitations. The only trouble with theory is that it is incomplete. Outside of pure mathematics, the most that theory can do is to draw a circle around the answer, and say that it is somewhere inside. To locate it exactly requires experience; but even then time and money are saved if, instead of relying upon haphazard observations of the results of ordinary work, an artificial experience for the definite purpose of determining the answer is undertaken according to the laws of experimental research. Also time and money are saved by first limiting the field for research, as much as possible, by the application of theory. If the principle of Records has been applied to the work of the organization in the past, the only research necessary may be the scientific study of those records.

Experimental and research work is best conducted separately, if possible, from regular production. The

two lines of work interfere with each other if the effort is made to conduct them together. As to research looking to new products and processes, it is best confided to a separate research or experimental department. Research on the conduct of existing processes is best confided to a separate staff whose whole duty it is to attain and maintain a high efficiency, and which is relieved from all responsibility for production.

The regular direct (commonly called productive) organization has all that it can do to get out the product by existing methods, without being called upon to devise improvements. It is like a man who is being chased by a bull. It is up to him to get over the ground. He may very highly value an automobile, but he is in no position to stop running long enough to start one. It is the duty of the efficiency staff to start the automobile of improvements, help the direct or line organization on board, and turn the steering wheel over to it. This does not mean that the staff, whose duty it is to offer advice and suggestions, should not welcome suggestions and advice from the line, whose duty it is to get out the product. Everybody connected with the organization should be encouraged to come out with any good ideas that may occur to him. (This is taken up again in Article 83.)

21. The mere problem of an adequate knowledge of theory is a formidable and, if it were put up to any one individual, quite insuperable matter. A working solution can be obtained, however, by taking competent counsel through the application of the principle of Organization.

The application of the above recommendations evidently requires specialization; the value of which, under the name of "division of labor," was one of the

first things to be recognized as a cause of industrial efficiency. However, the finer the specialization, the more numerous must be the personnel; hence, there are economic limits to its practical application. (Article 166 is devoted to the further consideration of this subject.) It is necessary, therefore, in treating the subject of Organization, to consider the problem of attaining the efficient discharge of all functions with the minimum number of people. This is a matter in which the large concern evidently has an advantage over a small one, but there are other matters equally important in which the small concern has the advantage.

22. In our effort to secure *higher* Common Sense, we must not forget that good plain *common sense* is just as important.

This faculty consists largely, if not altogether, in habitually forming judgments on practical questions. A judgment is a conclusion formed by comparing items of knowledge with each other. There is a natural tendency for the mind to challenge every item of new knowledge by all previous knowledge, and this tendency must be encouraged in order to cultivate common sense. Failure to do this is one of the commonest ways of allowing errors to be accepted by the mind and to pass over into practice.

A young officer of a ship was assigned the duty of checking a coal dealer's bill by measuring the volume of the coal pile as it lay on a lighter alongside. His results showed that the dealer had billed for considerably less than he had delivered. The captain at once exercised common sense by comparing this report with his experience of coal dealers, and judged the two to be incompatible. He therefore assigned an older officer

to check the work of the junior. The senior started out to measure the coal pile and found that the tape line was a foot short, whereby all dimensions reported by the junior were one foot too great. The junior had walked all around the coal pile, and had taken and averaged several measurements of its height, but he had failed to compare his result of six feet with the obvious facts that he was not six feet tall and yet could easily see over the coal pile at every point. In other words, he had failed to exercise common sense.

Obviously, common sense requires not only continual judgments, but also the fund of previous knowledge with which to make the comparisons; and this previous knowledge must come both from study and experience.

23. Right here comes the difficulty, for every business is practicing two arts, that of making its product and that of managing its affairs.

In a small plant, making the product is the big problem. The difficulties of management are small, almost inappreciable, in comparison. As a result, a small plant operated by a management that is both technically skilled and financially interested is often very efficient.

Unfortunately, this produces a tendency to ignore and even to despise the problems of management. As the business develops, the problems of management grow in more than a direct ratio. By and by it begins to be realized that the business is no longer as efficient as it was, although in its technical processes it may be as good as ever, or better. Finally, it may be realized that it is on the other side of the problem, that of management, that losses are occurring.

Evidently, knowledge of theory, practical experi-

ence, and the use of both by the exercise of Higher Common Sense are now as necessary on the management as on the technical side of the business. This ability in both lines, however, is not apt to be found in any one person. Either technique or management is so absorbing, that it is a rare individual who has the capacity to master both. This necessity for dual personality is one of the problems that must be solved by the application of the principle of Organization. And the separate persons must co-operate closely and harmoniously, which brings up one of the big problems of Personnel.

24. It is evident that management cannot succeed by dealing with events as they occur, but must foresee and forestall the events. This brings Higher Common Sense right to the front.

Take materials, for example. In order that the right materials may be obtained, there must be foreknowledge, derived from practical experience, of the requirements, not only of the working processes to which the materials will be subjected, but also of those processes that the finished article must meet in use. To determine how to meet these requirements, one must have scientific knowledge of the physical and chemical properties of the material in question, as well as of the processes by which it is produced. To determine whether the material as furnished actually possesses these properties, one must have scientific knowledge of the testing of materials.

The problem looks even more difficult if we consider an actual case in which sheet steel was to be worked in draw presses. The requirements of such a process are complex and severe, and the ability of the metal to meet them may be ruined by an error

either in its chemical composition or in the heat treatment or mechanical processes of its manufacture. Finally, it is difficult to conceive of any adaptation of the recognized methods of testing which would determine whether or not the material in thin sheets really possesses the required properties.

Scientific Research would undoubtedly establish a definite chemical composition and definite heat treatment and mechanical processes which could be depended upon to produce the required material; but this would take time and expense, during which losses would be occurring daily in the factory in trying to work unsuitable materials.

Common sense suggested that the desired knowledge was already in existence; that the users of the steel knew the processes through which it had to pass and the requirements of the finished articles, and that the makers of the steel knew its composition and the processes of its manufacture. The users and the makers were therefore brought together by inducing the former to furnish the latter, as a specification, samples of their product, finished and in various stages of manufacture, together with a complete statement of the manufacturing process through which each article passed. Reliable makers were easily found who took upon themselves the whole burden of so controlling their own manufacture as to produce the required material. When the question arose, how to determine whether the materials furnished conformed to specifications, Common Sense suggested that the draw presses themselves were the best testing machines for the purpose, and the steel makers established them as such by guaranteeing against loss by failure of their material in process of manufacture.

Obviously, the solution adopted was open to certain objections. It involved, in the first place, a departure from the previous policy of secrecy on the part of the users of the steel. Further, it involved their tying themselves to certain steel makers. For these reasons it is not offered as a desirable substitute in ordinary cases for the purchase of material in the open market on specifications, and its inspection and test by the users themselves; but it did furnish relief in a bad situation until more satisfactory permanent methods could be installed.

It has been said that "Science is foreknowledge," and it is evident that we can foresee the future in proportion as we thoroughly know conditions and the laws of nature. As our knowledge of both is imperfect, we can anticipate the future only approximately and for a limited time, but enough can be done to be of great industrial value. The working out of this idea leads to the development of the principle of Planning and Despatching.

25. Business tradition teaches that—

Wages must be low in order to have low costs; and that

A low ratio of overhead, or indirect, expense, is an indication of high efficiency.

The application of Higher Common Sense to these traditions shows them both to be fallacies. This has been discussed and emphasized so much by efficiency engineers that it would be out of place here to do more than refer the reader to the literature of the subject. Gantt has pointed out not only that these two traditions are fallacies, but that their general acceptance is among the most serious obstacles to industrial efficiency.

Among the most necessary applications of Higher Common Sense is the substitution of real knowledge for fads, fancies, and traditions. Harrington Emerson summarizes the situation in the aphorism, "Know the facts."

26. It is obvious that in many respects one cannot proceed directly to the application of Higher Common Sense. Just as analysis (Articles 1, 2, 3, and 5) shows Higher Common Sense to be the compound of all the other principles, so in practice we must synthesize it as the result of the application of all the other principles.

Chapter IV

IDEALS

27.

AN officer of the Pittsburgh and Lake Erie Railway, who was taking me over the line and pointing out to me the ways in which that road had worked for high efficiency, said among other things: "You notice that this road is located along the banks of the streams. This is a manufacturing region but the country is hilly, and flat land suitable for factory sites is to be found only along the banks of the streams. We foresaw that factories would want these sites, and located our road as you see. Then, when factories came in, we gave them the very best service. That brought more factories, and gave us a big freight business. Also our location on flat land gives us a road free from heavy grades, and enables us to haul big train loads."

Afterward, in talking with an officer of another road, I cited the Pittsburgh and Lake Erie as an example of efficiency. "Oh!" he exclaimed impatiently, "You can't talk about the Pittsburgh and Lake Erie. Any road could be efficient if it had their advantages. Their road is a procession of factories from one end to the other. And they haven't a grade on it of more than 3½ per cent."

"My dear sir," I replied, "the Pittsburgh and Lake Erie certainly has those advantages, but not by chance. Its management foresaw the need of those things and got after them. Now it has them."

In this matter, the Pittsburgh and Lake Erie management set two ideals clearly before itself—

The possession of a right-of-way along the banks of the streams, and

Excellent service to its customers.

It has pursued these ideals consistently for years, and it now profits by so doing.

The efficient manager adopts definite and correct ideals and gets after them resolutely and courageously. After he has stood the knocks and has conquered the difficulties, and begins to profit by the results, his less successful rivals complain that if they only had his luck they could have done equally well.

In order to get anywhere, it is necessary for the manager to have a clear idea of his destination and to stick to the road in spite of the bumps.

28. How about those lower down in the organization? In Article 8, I gave an instance in which the acceptance by a straw boss of the false Ideal of limitation of production proved a serious obstacle to efficiency. This ideal is widespread among workmen. In another case, a foreman's Ideal of graft nearly brought on a strike. (See Article 388.)

We well understand the necessity for team work; and it is evidently necessary in order to have it that the whole organization should be animated by the ideals of its chief.

On this point, Lieutenant Commander D. W. Knox, U. S. Navy, treating the same subject with particular reference to the naval service, and emphasizing the

absolute necessity for the subordinate officers to be of a single mind with their commander in chief, says:

> The body of junior commanders must be almost literally of one mind with their commander-in-chief and with each other, if frictionless and automatic team work is to be obtained. Their direction at every point should be unhesitatingly the same as would be given by the commander-in-chief himself were he present. Then, and only then, can the organization fully accomplish its purpose—unity of action in accordance with an expressed plan.
>
> The need for this type of understanding, as well as for the resulting concerted action, should be apparent to any one giving mature thought to the subject of command. It is recognized as a necessity in the principal foreign military organizations, and they attempt to supply the deficiency through what has been termed "doctrine."

"Doctrine" in this meaning is even broader than "Ideals" and requires further treatment under the principles of Personnel, Organization, and Discipline.

In the following chapter are three incidents of the methods of an industrial manager who was notably successful in permeating his whole organization with his own spirit, and they are interesting in this connection also. (See Articles 46, 47, and 50.)

Confining our attention for the present to Ideals, how is the manager to eradicate the wrong ideals of his subordinates and replace them by others which are correct, adequate and consistent with his own?

29. "Safety First." We are all familiar with this motto. It stares us in the face at every turn. Evidently it has produced a great effect. In itself and alone it seems to have accomplished much.

He who displays the sign, "Safety first," offers no reward for heeding it. On the other hand he evidently expects no selfish benefit from the warning. He gains

nothing, he gives nothing. Whoever heeds the warning does it for his own welfare, not that of the person who warned him.

There is, however, a strong hint of Discipline, of the sharp discipline of Nature herself. Whoever reads "Safety first" has brought vividly to mind the thought of grievous wounds, of maiming, and of sudden death, if he fails to heed. Even the addition, "It is better to be careful than crippled," which one sometimes sees, is so superfluous that it rarely appears.

However, at a difficult grade crossing, where an unseen locomotive may be upon one in less time than he can cross the track, the Instruction, "Stop—Look—Listen," in connection with "Safety first" is not amiss. In other words, if the Ideal is at all difficult of attainment, the principle of Instruction may also have to be applied before the Ideal can be realized. In Table 14, Article 236, is given an elaborate standard practice instruction to foremen for securing the safety of themselves and their men. Also there is absolutely a Fair Deal. "We have done our part," the sign seems to say, "you are warned. We set no arbitrary penalties. The risk is your own. Do as you please."

30. The following is a circular issued to propagate the Ideal of courtesy:

The following expression to its agents, conductors, and other representatives indicates the attitude of the Lackawanna Railroad on a subject of vital interest to its patrons:

The possession in marked degree of any faculty should always be an incentive to develop that faculty. This company considers that its agents, conductors, and other representatives possess above the average the faculty of being courteous to the public. To those who cultivate and exercise this faculty the company extends its congratulations and thanks; to those who do not fully appreciate its importance, careful consideration of the following is suggested:

First: The principle that underlies courteous treatment of others is simply that of doing unto others as you would they should do to you.

Second: In a highly complex and complicated business such as that of the railroad there are many things that you, with your training and daily experience, understand with perfect familiarity, but which the public do not understand; therefore, do not assume that the public should comprehend them without asking questions, but, when inquiry is made of you, give the courtesy of a reply just as full and clear as you can make it, and without any suggestion of superiority born of a greater knowledge.

Third: Words are only one means of expression, and manner is quite as important; therefore, remember that a kindly and gracious manner is not only the sign and mark of a self-respecting man, but is to your words what oil is to machinery in making them move effectively to their purpose.

Fourth: True courtesy is no respecter of persons. It remembers that "a man's a man for a' that," and gives the civil word and the helping hand as readily to the ill-clad stranger as to the official of the Company.

Fifth: Courtesy is not only something the public have a right to expect of you, but it pays.

It pays in the friends it makes to you personally and as representatives of the Company.

It pays in minimizing the friction of your life, as well as that between the company and its patrons.

It pays in raising your standing with the Company.

It pays in the personal satisfaction resulting from having done the right and kindly thing by your "neighbor."

It is the wish of the management of this Company that all its representatives, whose work brings them into contact with the public, may appreciate and fully measure up to their duty and privilege in this respect.

While the railroad would probably not claim any altruistic motive in this expression, at least it must be given credit for enlightened selfishness. The road does ask something for itself, but that something is of vague and intangible value, and the company's benefit from it is indirect and uncertain. On the other hand, the employee's gain from the practice of courtesy is

direct, immediate, and certain. There is, therefore, little need to offer any prospect of reward by the railroad for the pursuit of the ideal, and it is only hinted at in the words, "It pays in raising your standing with the company."

For the same reasons, there is little need to back up by discipline the propagation of the ideal of courtesy; but even in such a case the principle of Discipline cannot be entirely ignored, and there is some hint of discipline in the words above quoted and in the closing paragraph, "It is the wish of the management of this company that all its representatives, whose work brings them into contact with the public, may appreciate and fully measure up to their duty in this respect."

Courtesy is a virtue which, even if appreciated, may not be attained. Some simply do not know how to be courteous. Moreover, the task of the railroad conductor, trainman, or ticket agent in trying always to be courteous to all sorts and conditions of men, women, and children, many of whom are anything but courteous to him, is not easy. Hence, about half of the expression is taken up by Instruction as to how the Ideal may be attained.

Again, there is a Fair Deal. The desirability of courtesy is pointed out and how to attain it, and the most valuable rewards are sure and automatic. Even if the employee's courtesy should be so unnoticed as utterly to fail to "raise his standing with the company," his probable reward will not thereby be appreciably diminished.

31. The next example of propagation of an Ideal is quoted from an article by Forest Crissey in the *Saturday Evening Post:*

"Going After the Extra Nickels"

The possibilities of a big sales force thoroughly trained in salesmanship and kept in a glow of enthusiasm for its work, are wonderful. I did not realize the responsiveness of such an organization until I put it to the test with a letter headed: Get that extra nickel! This was sent to every store employee in the chain and to those of the central staff who made the rounds of the stores. In substance this letter read:

"The stores of this chain make twenty-five million sales a year. Just think of what it would mean to this organization if all the clerks and telephone operators would speed up their salesmanship to a notch that would get an average of just one extra nickel on each sale! Figure it out for yourselves. It would mean a million and a quarter dollars in additional business, secured without an additional cent of cost. And it would mean increased pay for our whole sales force. You know that your salaries are already higher than those paid by stores outside of the chain to employees in positions similar to yours, and that you have far more attractive working conditions.

"Now if you will put your shoulders to the wheel for a long, steady, constant pull to get that extra nickel on each sale, we shall be able to do still more for you in your pay envelope. Will you do it? Let us hear from you both by letter and through the sales report."

The result of this letter was an immediate increase in sales that was sensational in its size. And it was not a mere passing spurt, either. Our clerks held to their quickened pace with wonderful persistence, with the result that our profits in that year were greatly increased—just how much I am not at liberty to say; and our employees who helped to bring this result about secured their fair share of the increase. But the whole point of this incident is that there is always extra speed in a sales force picked, trained, and treated with the care ours receives. The splendid results of the "extra nickel" campaign were possible only because our clerks were so thoroughly instructed in the art of constructive salesmanship, and because we had their enthusiastic loyalty.

32. There is one big difference between this case of propagation of an Ideal and the two preceding. In this last, the employer is asking his employees to do

something distinctly for his benefit. The company's interest in the matter is immediate and entirely selfish. Note then how much more prominent the reward is in this example than in the two preceding. It is plainly promised and in the most tangible form—increased pay. Also the promise was kept, "Our employees who helped to bring this result about secured their fair share of the increase."

This shades off from Efficiency Reward into the Fair Deal, which is also made prominent in the statement, "Your salaries are already higher than those paid by stores outside of the chain to employees in positions similar to yours, and you have far more attractive working conditions."

After one has read the chapter on Discipline, Chapter XIII, and fully understands the meaning of it as an efficiency principle, he will see that it is emphasized by the foregoing expressions, "Kept in a glow of enthusiasm for its work," "The responsiveness of such an organization," "If you will put your shoulder to the wheel for a long, steady, constant pull," and, "We had their enthusiastic loyalty."

As for Instruction, it is evident that the notice itself was not sufficient to contain it, and that there had been long, persistent, and skillful instruction of the whole salesforce before the results could be accomplished or even suggested. This is also evident from a further statement of the methods of this concern in Article 59.

33. The examples of Articles 29 to 32 show that any effort to propagate an ideal must, to be successful, be accompanied or preceded by the application of the Fair Deal, Discipline, Instruction, and Efficiency Reward; that instruction must be in proportion to the difficulty

of attaining the ideal, and that the Fair Deal and Efficiency Reward must be in proportion to the propagator's own selfish interest in the success of his propaganda. Even Jesus, while He devoted so much of His attention to Instruction, and by the example of His own life exalted the Fair Deal and determined the Discipline of His church, yet found it necessary to pronounce eternal punishment upon the disobedient and to promise eternal bliss to the faithful. And wherever belief in Heaven and Hell grows weak, Christian propaganda languishes.

34. The walls of some factories are abundantly plastered with the following:

> Every man should work and feel that he is a part of the firm and not merely a *hired* man. He should look after the business as though he owned it; and feel that, if he in any way neglected his work, the business would suffer.

Every employer who puts this up ought very seriously to ask himself:

Has the worker who reads it ever been made, in the least, a part of the firm?

Has he ever been encouraged to make suggestions?

Is he in reality anything more than a hired man?

Has he, in any tangible way that directly appeals to him aside from the mere holding of his job, been given any reason to care whether his neglect causes the business to suffer?

If all these questions can be answered satisfactorily the posting of such a notice will probably be unnecessary; but, if there has been absence of the Fair Deal and of Instruction, if there is barely so much Discipline as there must be to do business at all, and if there is no adequate Efficiency Reward, such a notice will arouse among the workers no response but derision.

Chapter V

PERSONNEL

35.

A FACTORY foreman explained to me his method of securing and keeping proper help. If possible, he hired only unskilled labor; that is, he took on only laborers and boys. A newly hired, unskilled worker was shifted about all over the department, wherever there might be need of his labor. Whenever there was an opportunity, this foreman would place some of his unskilled workers as learners with men who were doing skilled work. He kept some kind of a record, perhaps only mental, of the proficiency shown by these learners at the various operations of the department. If one of them showed more ability along one line than along others, his instruction was specialized as much as possible along the line of his fitness. When a vacancy occurred among the helpers, or among other workers having a small degree of skill, the boy or laborer who had shown the most skill in that work was moved up into it, and a new unskilled worker was taken on. Similarly, vacancies among the skilled men were filled from among the helpers.

By this means the foreman had built up a department in which he thoroughly knew all of his workers,

except those unimportant ones who could be replaced off the street on short notice at any time. His men knew that, in so far as it was in the foreman's power, they could depend upon permanence of employment and promotion up to the limits of their own skill and the opportunities of the department; in other words, they could depend upon the Fair Deal. Consequently, they were contented and stayed on.

Also, the foreman took all his risks in the positions of least importance. When it came time to fill any position higher up, the foreman had a candidate for it whom he had tried out, and whose fitness for the position he knew.

36. The method is both simple and effective, and it is a wonder that it is not more practiced. One of its evident virtues is that it conduces to *permanence* of Personnel; and this permanence is necessary (among other reasons) in order that the organization may be so permeated with the spirit of its chief as to attain the degree of team work essential for success, as previously mentioned in the chapter on Ideals in connection with military "doctrine" (Article 28).

On this point, Commander Schofield, U. S. N., has said: "In a military service, where many intellects must co-operate toward a single aim, and where the stress of events forbids the actual interchange of ideas, . . . there must be a governing idea to which every situation may be referred and from which there may be derived a sound course of action. It is only thus that the full driving power of an organization can make itself felt."

Again, in discussing the situation confronting the commander of a fleet on the night preceding a probable battle, the same officer says: "No verbose instruc-

tions that he may issue now can have the remotest chance of converting an organization of form into an organization of intellect and spirit. Such a change is a matter of long and patient educational effort that eventually centers around a doctrine of military conduct to which every act either of preparation or of execution is automatically referred. When such a stage of development is achieved, a spirit of confidence becomes diffused throughout the service that invests it with a moral power of the greatest value."

How many concerns are intelligently striving for permanence of personnel?

How many concerns make a practice of hiring new people only at the bottom, and of promoting one of their own men, if possible, instead of bringing in an outsider?

How many concerns make any effort to have their employees taught the duties of their own and of higher positions, even in time in which they could not otherwise be profitably employed?

How many concerns provide a regular flow of promotion for their employees?

How many concerns are qualified, by definite knowledge of the fitness of their employees, to make promotions strictly on merit?

How many of them would do it even if they had the knowledge?

37. Many foremen will hire off the street a man who claims to be a machine operator, rather than to take the trouble to teach one of their own helpers. Even a managing director of a company, in reference to the officials of the company, said to me, "We have always gone on the principle of hiring a man from the outside rather than of promoting one of our own men,

because we felt that if we made the promotion, we had to train two men, while the other way we had to train only one."

So far was he wrong that by the application of Instruction before the vacancy occurs, and of the Fair Deal in filling it when it does occur, the man for the position is already trained and steps right into it. All down the line there is a similar upward move of people already trained, and a new worker comes in at the bottom, all without disturbance or delay.

It is true that one seldom finds a shop boy or a laborer who is capable of developing to fill important positions, though there are some such and their exceptional talent should have its opportunity; but the rareness of it obliges the employer to have several ladders of promotion, each with its own bottom rung and successive upward steps.

On these principles, military services, while affording some promotions from the ranks, in the main admit their commissioned personnel in the lowest ranks of cadet corps. Similarly, large industries have been obliged to organize student apprentice corps, at the bottom of which graduates of technical colleges are admitted, and from which they normally rise to official positions.

A military service, besides providing promotions from the ranks to commissions for those rare individuals who are fit for them, provides for the man of ordinary ability a career in promotion to non-commissioned and warrant rank. Similarly industry, recognizing the rarity of the workman who can become an officer of the company, ought to offer to the competent industrial private reasonable prospect of rising to minor executive positions.

In spite of the best efforts there will be an occasional time when there is no work available for some one. By applying the principles of Planning, this ought to be foreseen and Instruction ought to be provided for that person during his otherwise idle time. This does not mean that some one must stop work to teach him, though perhaps that can be planned for out of the otherwise idle time of the teacher. In the main, it means only giving him a chance at the work he is to learn. Also, there will be times of temporary absences which can be filled by temporary promotions all the way down. In these and other ways Instruction can be provided at a minimum of expense.

This leads to the subject of understudies, which is discussed at length in Article 252.

38. We may analyze the problem of Personnel into two parts:

First, to get the right person into every position; and

Second, to keep him in it as long as his services are available, or until efficiency can be increased by his promotion.

39. The problem of getting the right person into every position can be attacked in two ways:

First, the requirements of the position and the qualifications of the person can be studied, and the most suitable person available can be selected; and

Second, the system of recruiting and promotion stated in Article 35 can be used so as to minimize the errors of selection.

40. In tackling the problem along the second line, we must be prepared for a certain amount of failure of any scheme of instruction and promotion of our own men to fill all the vacancies that occur. Progress and

change in industry occasionally produce needs for which our own methods have not trained any one. Casualties and opportunities elsewhere may deprive us of our available material just when the need arises for it. Therefore, we shall occasionally be obliged to fill positions anywhere along the line from the outside, instead of following the preferred scheme of always filling in at the bottom.

It is probably just as well that this is so. Too complete application of the preferred method produces the effects of excessive inbreeding, so that it is desirable to bring in occasional new blood and new ideas from outside. This need not cause any anxiety, because it will probably never be possible to work the preferred scheme to excess.

41. A candidate who would be considered at all for a position as important as that of foreman or head of an office department, or for any higher position, must necessarily have some verifiable record which furnishes a sufficient indication of his fitness. I have myself applied this method to such positions with unvaried success. If one advertises his needs at all broadly, there are always enough applicants for such a position to give a good field from which to choose. Personally, I have never known such a field to fail to offer at least one competent person.

42. It is necessary in filling a vacancy by this method to give more than usual attention to three points:

Moral character,
Capacity for work, and
Health.

Employers are apt to be a little shy about inquiring about moral character. They are properly reluctant to ask any questions about one's religion, and they

seem to consider moral character in the same category. Judaism and Christianity have wedded the two, but still they are separate things; and inquiries into a man's record for honesty do not involve any investigation of his theology.

The result has been to neglect investigation of character somewhat; while, obviously, the lack of character puts the minus sign before all other good qualities that one may possess.

43. The difficulty in the application of this method is that there are many positions of considerable importance for which candidates are apt not to have any records that are capable of verification. This difficulty ought not to continue to exist. I quote from Sidney Graves Koon:

> A large machine-tool company in Connecticut keeps careful man records, available from day to day and extending over months and years. These enable the management to promote the best men and to weed out incompetents on a basis so sure that error is practicably negligible. They also form a basis from which a man's record can be certified to a subsequent employer, without depending upon the uncertain and perhaps prejudiced memory of a foreman. The man's standing and general capabilities, along the particular lines for which he was used, are known at all times and in any detail desired. Not only is the individual record thus given, but also the general standing of any department or sub-department. The standing of the man as applied to a particular character or class of work is known and many other features of his employment and use, all of which are of decided interest and advantage to a progressive management.

Associations of employers ought to call the attention of their members to the great value to them all of the general application of the principles of Records and Standards, as Koon has above explained. If there were general application of these principles, a

reference by an applicant to a previous employer would bring out information that would be both adequate and reliable. An applicant without reference would then be regarded as previously unemployed, or as of previous bad record, and in either case admissible only on probation and to the ranks of unskilled workers. Such methods as are here advocated are already coming into use by the combined action of employers in some localities, but generally without adequate application of the principle of Standards. Obviously, a man's record of achievement may work positive injustice, unless by the application of a fair Standard the efficiency of the achievement can be quantitatively estimated and recorded.

44. The selection of a competent person for any position is a highly skilled operation and, by our present methods, one usually entrusted to persons who have no fitness for it. Commonly, every foreman hires his own men directly. A foreman ought to be skilled in the art practiced in his department, he ought to be capable of instructing his workers in it, and he ought to have minor executive ability. These requirements are enough to occupy him fully; and when, in addition, he is expected to be an employment expert, it is no wonder that he falls short.

Recognizing that employment work is a specialty, logically a specialist ought to be used for it. There are enough routine requirements of such work to place it beyond the powers of one who has anything else to do. These requirements embrace the search of the labor market, especially the local one, for available material; the keeping of adequate and reliable records of such material; the investigation of previous records of applicants; communication with applicants when

their services are wanted, and the keeping of records of employees after their services are engaged. Added to these duties are others of a highly skilled nature. These include: listing the human requirements of various positions; interviewing applicants and judging their fitness for particular employments; selection of candidates who, while technically fit, are also suited to their human environment, especially to the personalities of their immediate superiors; the selection of at least one understudy to every skilled worker; and the adjustment of personal difficulties among the working force, especially those between workers and their immediate superiors.

Referring again to the requirements of

Technical skill,
Moral character,
Capacity for work, and
Health;

such skill as should be possessed by a specialist in employment makes him a much better judge of the last three than any one can be whose attention has been engrossed with the matter of technical skill. Your foreman could never form a competent judgment on your general health. Your family physician or a life insurance examiner will do it reliably in an hour or less. It is easily possible for the employment supervisor to acquire enough of the physician's skill in this matter to make in even less time as good an estimate of health as is required for most employments. For those requirements that are beyond him, he should have the competent counsel of a physician. No one would employ as blacksmith's helper a man of slight figure and small muscular development, no matter how good his general health might be; but questions of one's

relative fitness for sedentary or active labor, for running an elevator or helping a machine operator, are not so obvious to the unskilled judgment, but may be perfectly plain to one who has specialized in such matters. Moral errors also leave traces which are readily discernible to the skilled observer.

Employment is too big a matter to be handled adequately in any treatment of the general subject of efficiency, and those further interested must refer to the literature on that specialty. My present point is that it is a highly skilled specialty, and therefore ought to be taken out of the hands of people who know nothing about it and be confided to some person competent to handle it. Obviously, in the case of the small concern, we are again up against the difficulty of specializing, but the needs of it are so great that it would be well for such employers to combine locally and maintain a joint employment bureau under competent management.

45. On the other hand, the employment supervisor can not be expected to be a competent judge of technical requirements. His function in that respect should be limited to obtaining and summarizing such details of the applicant's record, if any, as bear on the subject. He should then pass the applicant and his summarized record on to some competent person, probably the foreman of the department in which the work is done, for examination and report.

Also questions of race, religion, and temperament require the co-operation of the line organization with the employment supervisor to secure the best results. Nothing but trouble is invited by placing a white American under a straw boss of any other race than the Caucasian. A rationalist in religion and a zealous

proselyting adherent of dogma are not apt to get along together, no matter which is boss and which is worker. Similarly, people who are of quick, active, nervous temperament and those who are slow, painstaking, and phlegmatic are usually a mutual irritation. For these reasons any foreman or other executive should have veto power over the selections of the employment supervisor; that is, while the latter should search the available material and, with the assistance of the technical expert, should select the person to be recommended for employment, the foreman or other boss should always have the right, after trial, to reject any applicant, and to send him back to the employment supervisor for the mere reason that he is not personally agreeable to the boss.

46. Of course, the boss himself may abuse this privilege. If he does so grossly, it will at once become apparent, and the employment supervisor ought to settle the matter immediately by an appeal to the boss's line superiors. Less obvious error of the boss ought to be detected by the application of the principles of Standards and of Records, and be corrected by the application of Common Sense.

The following extract from an article by Edward Mott Woolley, published in the *Saturday Evening Post,* will make my meaning clear:

As the business grew, the individual contact of the chief executive necessarily was confined more and more to the higher executives; yet even today, "the spirit of the house," as he calls it, is the identical spirit of its head. It filters down through the organization.

Here is an instance of how it filters:

Within the last year the president of the company sent for the executive head of one division.

"I find from my statistics," he said, "that your division

shows the highest percentage of quits and discharges. You are away above the normal and we must find out where the trouble lies.''

Then they had a special research made. Every man who had left the employ of the house during the year, as far as that division was concerned, was communicated with, either in person or by letter. To each man these questions were put:

If you left voluntarily, what were the inner motives that prompted your act? And if your departure was not voluntary, in what measure do you consider the house to blame for the differences that led to your going?

Nearly all the men returned some sort of an answer. One minor executive, who had resigned to go to another house, explained the thing in substance like this:

''I had been in the accounting department three years without making much progress. I was tired of the job and didn't see any future ahead. It looked to me as though the house was so big that it had about reached its limit, especially in that line of work; so I looked around and got a job with a good lively house, where I had more chance to swing myself, to put in new ideas and draw more money.''

To the president this was something of an eye opener.

''We haven't been handling this man right,'' he said, ''if we have allowed him even to imagine that ideas weren't worth as much to us as to any other house, big or little.''

This led to a scrutiny of the accounting department.

''Is it true,'' asked the president, ''that we have developed this department to its limit? We have been priding ourselves that we had a good accounting department; but perhaps it has been mere self flattery.''

He ordered a research made into the methods of accounting departments in other large concerns, and this showed him that his own had been lacking in modern ideas. The executive was hired again and given authority to dig up all the ideas he could and to try them out. This resulted in a new auditing department of which he was made the head.

It resulted, too, in a policy of keeping track systematically of all the men who leave the company's employ, as far as it can be done without prohibitive effort. Regular reports on these men are made to the president, who goes over the records and finds in them a lot of things to think about.

One man who had left the house to establish a business of his own was found to be prospering in an unusual way.

"Why did we let him go?" asked the president. "We should be better analysts of men than that. With our great opportunities here in this business we can offer men of that kind inducements which will keep them with us. We must not let men of this caliber get away so easily."

Then he sent a telegram to his former executive, who had succeeded as a merchant by himself, and invited him to take a train that night and come to the old stand for a conference. Shortly after the big house absorbed the offshoot, and the owner of the latter became once more a member of the great organization. He is now a vice-president.

It is the aim of the house to get back sooner or later every exceptionally good executive who has left.

Another discharged employee, on being asked why he considered the house to blame for his downfall, named a certain superior and said very uncomplimentary things about him. No special weight was attached to this until several other discharged employees referred in an uncomplimentary way to this same superior. They called him names, such as toad, rat, lobster and perhaps skunk. I am not sure about that. At any rate, they made quite a menagerie of him.

Out of this grew a close analysis of this man, and he was quietly superseded by somebody else who was in better accord with that shrewd spirit which says that men must be handled psychologically, so as to bring out all of their good points and strongest efforts.

47. According to Woolley's account, the house in question applies these principles not merely to cure such troubles after they have occurred, but to prevent them. He gives the following example later in his article.

Some twelve years ago a youth applied at this house for a job. It is told of him that while waiting in the employment room he killed time by throwing paper wads at the other applicants, and got into an altercation that in any other employment department would have finished him on the spot. Oddly enough in this house the very fact that he threw paper wads attracted attention to him—not exactly favorable attention, but a certain degree of curiosity. This curiosity was nothing more nor less than the spirit of the president filtered down to the manager of the employment department.

The boy was nothing extraordinary; on the contrary, he measured up pretty scant when it came to the problem of twenty-six plus eighteen plus one—or something of that sort. He got the answer forty-seven—or something relatively as far from the correct one. He wrote uphill and went downhill on grammatical construction. But for some singular reason, he got by and was put on the eligible list; and a few weeks later he was notified to report for work.

They put him in a stock room at six dollars a week. On the second day, the president walking through, got a first glimpse of him. He had a feather duster run down his back inside his shirt, and the feathers were waving over his yellow hair. He was a Comanche Indian, and he was executing a death dance.

You will remember that the president is an analyst of men; also of boys. So, instead of rebuking this boy, he went along and asked himself:

What impulse moved him to undertake that violent exertion when he might have sat down and taken some leisure?

The president, following his system, resolved to find out. Next day, the boy was taken out of that particular stock room and put into another where the work was heavier and the help short. Nevertheless, he exhibited a surplus of energy and carried the additional burden without any complaint or let-down. Between jobs he practiced standing on his head.

Then the youth was moved up again and some responsibility was added to his physical duties. Every time he broke out into an Indian dance or similar exuberance they gave him something to absorb his enthusiasm. At the behest of the president he was watched shrewdly, and periodical reports were made on his progress.

He went up rapidly, and in the course of a few years became sales manager, which position he now occupies. It was his irrepressible enthusiasm that did it. The president and the organization simply harnessed it.

This is an exceptional instance only in degree. The same thing is being done in that house right along.

The discovery of the boy's overflowing enthusiasm and energy ought not to have depended upon a chance visit of the president of the company.

A manager who depended upon such chance knowl-

edge once promoted a man because he turned out his light when the manager happened personally to call him away from his work. There was an immediate epidemic of turning out lights, followed by the complaint from the rest of the force that they also had turned out their lights and had not been promoted, to which the sequel was a general grouch.

Instead, every worker's efficiency ought to be known daily by current records compared with fair standards; and the possession of valuable qualities, or the contrary, not made apparent by an arithmetical percentage of efficiency, ought to be made known regularly to the employment supervisor by systematic reports from executives on their experience of their subordinates. One of the most useful functions of the employment supervisor is to study all these records in order to determine the qualifications of every individual and, as soon as possible, to locate him in the employment for which he is best suited. These records are also very valuable aids to Discipline. (See Article 275.)

48. It is a wonder that the boy in the story just told was not fired by the store-keeper to whose stock room he was first assigned. If he had been, a valuable man would have been lost to the house, and not by any fault of the store-keeper, but from lack of adequate attention by a competent person. To avoid such losses, discharged employees ought to be referred to the employment supervisor, and the latter ought, if he considers the person so discharged to be capable of valuable service, to transfer him to some other situation. If there is no chance for that, he can keep him on the eligible list for suitable employment when the vacancy occurs.

Magnus W. Alexander has calculated that it costs from $8.50 to $73.50 to change a single employee. It is therefore evident that one of the most valuable features of the employment supervisor's work is to secure permanence of personnel. To this end he may at times be able to induce executives to rescind discharges made in error and to allow the discharged employee to return to his previous work. (See also Article 277.)

49. Since personnel is one of the primary principles of efficiency, it is evident that its application is one of the quickest ways to get results. On the one hand, this emphasizes the importance of employment work, such as has been discussed above; and on the other hand, it brings out the possibility of securing results promptly by filling the important positions with the right people. One of the main resources of persons in financial control is to hire a superintendent or manager; put it up to him to make good; judge him by results, in entire ignorance of conditions; and replace him by some one else if those results are not promptly forthcoming. This method has the disadvantage of resorting to a capital surgical operation for the cure of what on scientific diagnosis would perhaps be found to be minor ailments.

In other words, if an organization is inefficient, it is usually well to reserve drastic changes in the personnel of important positions until there has been a general application of the Principles of Efficiency in other directions. If this is done, it may be found that the apparently offending officers were really doing remarkably well under adverse conditions and that the improvement of those conditions, not the removal of the officer, is the thing needed to secure an increased efficiency.

50. Once the position has been filled by the right person, there remains the problem of keeping him. In the first place, the work must be made as agreeable as is commercially profitable by the adaptation of the work and the conditions to each other. In one large factory which I investigated, I found that there was difficulty in getting and keeping good female help. On seeking the reasons for this, it was found that the plant was remote from the residence districts of the class of women that it desired to attract, and that to get to and from the factory they had to ride long distances through rough neighborhoods at hours when the cars were crowded with the lowest class of male workers, including negroes. This was a condition to which the women who were wanted would not submit. The use of jitney busses every night and morning might have solved this difficulty. Similarly, a draughtsman who values his sight as he ought will not stay nor can he work efficiently in ill-lighted drawing rooms.

Placing the worker in the position for which he is suited is itself an important Adaptation of Conditions for this purpose. Woolley's article again furnishes a good illustration:

The early researches of the president of this house showed him that it is not merely financial incentive to which men respond, but that genuine interest in their work is quite as much of a puller. Therefore, he studied men's characteristics, so that he might place them in the lines of work for which they were mentally suited.

When he established a statistical bureau he tried an experiment. After his statistical manager had been in that position six months, another job in the house was offered him at an advance of five dollars a week. He had been getting thirty-five. He took the new job in a hurry.

Then another statistical man was picked out; and in a few months he too was offered an advance in another line of

work. He took it without hesitation. This was repeated several times with the same result. Then the president went outside of the house and found a man who was pre-eminently adapted for the work. He was hired at thirty-five dollars a week. Three months later he was tempted by the president with an entirely different sort of job at forty dollars a week; but that afternoon he went to the president's office.

"I've been thinking about this matter," he said, "and I believe I'll stay where I am, if it is all the same to you. I like the work I'm doing now. I'm built for it and I can fairly eat it up. I don't think I should like that outside job."

This and other experiments led the president to conclude that much might be accomplished by getting men to take a more genuine interest in their work, even though it was not possible always to duplicate this episode of the statistician.

Besides fitting the man to his place, if he is to be kept hope must be held out to him in the shape of a regular system of promotion, and in every other way the Fair Deal and Efficiency Reward must be applied by methods suited to the conditions.

Chapter VI

ORGANIZATION

51.

THE backbone of Organization is the Chain of Command, which Colonel Foster explains as follows: "It is obvious that the commander of a military force cannot deal personally and directly with all those under his command, but only with a limited number of subordinate commanders. Each of the latter in turn conveys his will to his own subordinates, and this gradually broadening system, called the Chain of Command, is carried on till every individual of the force receives his orders. These orders are founded on the original orders of the Commander in Chief, with modifications and details added by each lower in authority in the chain so as to suit the special circumstances of his own command."

It is equally obvious that the head of any except a very small organization cannot deal personally and directly with all those under his command; and consequently that he also must have a Chain of Command through which to make his will effective.

52. Analyzing Foster's statement, we find the elements of organization and orders as further tabulated on the following page:

The Organization

A Commander-in-Chief,

A limited number of commanders immediately subordinate to the chief, who alone deal directly with him,

Other commanders subordinate to these, and others again subordinate to them in a definite gradation of authority,

And finally, the individuals, or "privates" of the force.

The Orders

The original order of the chief,

And modifications and details by each lower in the chain, so as to suit the *special* circumstances of his own command.

Let us consider these elements.

53. A self-made man had built up a successful manufacturing business. His own practical experience being limited to selling, he depended largely upon his department heads in other matters. He paid good salaries, and collected able men about him as his "limited number of subordinate commanders." To these men he strongly applied the principles of Standards, of Records, of Discipline, and of Efficiency Reward. By means of Standards, he knew what they ought to accomplish; by means of Records, he knew what they did accomplish; by Discipline and Efficiency Reward, he both drove and stimulated them to achievement. In the life of the founder of the business these methods were very successful. He died, and his son succeeded to the management. The young man had been brought up as a rich man's son, and would not under any cir-

cumstances give more than a very small portion of his time to the business. Only men who were not only strong and able, but also good fighters, had been able to survive as the immediate subordinates of the father. Under his strong rule they worked harmoniously together; but when the son's inattention loosened the bonds of Discipline, they fell to fighting among themselves to the damage of the business.

Evidently this was a case of fundamental inefficiency due to the lack of an adequate first link in the Chain of Command, the Commander-in-Chief himself.

Of course, this lack cannot exist in the first generation of control; but the notorious fact that an American business seldom survives three generations of management by the same family, indicates that it is very common where managements have been inherited.

In any case, it is absolutely incompatible with efficiency; and any family that has inherited a business would be wise to ask itself, without any attempt at evasion, whether it has also bred a monarch capable of ruling its kingdom. If it has not, it had better without delay convert itself into a constitutional monarchy, choose a capable prime minister in the shape of a general manager fit to run the business, allow him to govern, and be satisfied itself merely to reign.

There is a majestic example of the success of this policy on the scale of world-wide empire; but there is so much tendency for the Pepins to make themselves kings, that the incompetents would probably do well to sell out and put what is left of the estate into government bonds.

The function of the Commander-in-Chief, or General Manager, evidently is to deal with his immediate subordinate commanders. Also, that is about his limit.

We are greatly impressed by the stories of Haroun-al-Raschid prowling around Bagdad in disguise to see for himself what went on; and his policy was all to the good provided it did not take too much of his time; but we cannot help wondering whether some of his adventures did not interfere seriously with his own job as Caliph.

If the Big Chief can manage to look in personally often enough, so that no one in the whole place will ever feel sure that the Old Man will not be standing at his elbow the next minute, he has done all that can be expected of him in this line; and even that may take him away from his own work too much. Records, Standards, Discipline, and Efficiency Reward, as stated at the beginning of this article, provide him a way out which is much more certain and which does not make such demands on his time.

The president of the company sits at his desk in his private office. On another floor and directly over his head, a mechanic is filing at the bench. The workman's attention is wholly concentrated on one particular spot of metal, but his consciousness is no more closely focussed on that spot than is that of the president on the particular sentence which he happens at that moment to be reading in a report. The field of the mechanic's attention is ample for the demands upon it, but how about that of the president? Seeing that the only field upon which he can at that instant exert his intellect, is the little spot which is momentarily illuminated by the pocket flash-light of consciousness, how is the necessary information about the business to be focussed in that little spot?

A client said to me, "We have a mass of records, but they fail to give a bird's-eye view of the business."

Here is a problem which must be discussed under the principle of Records (Article 132), that is, how to design records which will bring to every one in the organization just the information that he needs, and so concentrated that he can seize upon it and act on it in the time available for the purpose.

Supposing this problem to have been solved to a working approximation at least and that comparison with a fair Standard shows the efficiency of every event, the chief then has the knowledge which enables him to apply the principles of Discipline and Efficiency Reward with substantial accuracy and justice to his own immediate subordinates, and therefore to transmit his will effectively to the next link in the Chain of Command.

54. We have to turn now from the Commander-in-Chief to the Order. Nature has had an experience of untold ages in Organization, and experiments which have survived the merciless struggle for life are marvellously efficient.

However, in taking lessons from Nature we need to remember the artists' maxim, "That which imitates Nature is hideous, that which is inspired by Nature is beautiful." In engineering, we might paraphrase this to, "That which imitates Nature is clumsy, that which is inspired by Nature is efficient." P. T. Barnum once exhibited an apparatus about as big as a pipe organ, built in the closest possible imitation of the human throat and vocal organs, which slowly and barely intelligibly spoke a few words. How different the phonograph, whose design imitates nothing in Nature, but which is inspired by Nature.

John H. Van Deventer has published an excellent study of the human body under the title, "The Ulti-

mate Type of Management,"[1] in which he has this to say about its order system:

We have something to learn from the model plant in this connection. The general manager (the cerebrum) does not take the time to give detailed orders. They are of the briefest description and to the point. His subordinates enlarge them and supply the details. He will say, "Let us go out for a walk." The action manager (the cerebellum) subdivides this order into, "Arise from the chair. Walk to the hat rack. Pick out your hat and put it on. Open the door and pass out." Each of these is again subdivided into detailed orders for the muscles involved by the reflex centers or department heads. For any such simple action as above the detailed orders run into the hundreds. How long would it take you, for instance, to tell each muscle what to do in order to make you rise from your chair? You would have hard work to get all the necessary itemized commands on this page, even with fine type.

Referring again to the analysis of the Chain of Command, and bearing in mind Van Deventer's study of the order system of the human body, we see that modifications and details added by each lower in authority in the chain are to suit the *special* circumstances of his own command. Evidently, if there were no special circumstances, that is, if all conditions throughout the business were completely adapted, the chief could himself give orders which would carry without modification or addition of detail to their ultimate application. We are, of course, required to suppose that the chief has a central planning department to relieve him of the burden of personally working out the details of such orders.

However, a moment's reflection will show that any such thing as absolutely complete adaptation of conditions is quite unattainable. In the measure that con-

[1] *The Engineering Magazine,* June, 1915.

ditions are special, or unadapted, they can be known only by actual contact with them; and hence dealing with them must be left to the one who is in such contact.

This gives rise to the necessity for dividing the order into two parts and of leaving to each lower authority the power to modify and to add detail.

Hence, in giving any order, the chief has two problems:

To set clearly before the subordinate the proper Ideal and limits outside of which the subordinate has no discretion; and

To allow the subordinate full discretion within those limits.

The second part of the problem is of no less importance than the first and is equally necessary to efficient performance.

In our industrial management the limits of discretion allowed to subordinates have usually been altogether too wide. In fact, everything has consisted in "putting it up to" somebody or other. The president puts it up to the general manager, the latter to the factory manager, he to the superintendents and foremen, and they at last to the men. For everybody it has been simply a more or less vague responsibility, often excessively and unreasonably enforced, and full discretion. It is no wonder that efficiency engineers, recognizing this as a cause of inefficiency, have sometimes by a natural reaction gone too far in the other direction and have tended too much to prescribe everything from above and to deprive the successive links of the Chain of Command of their necessary discretion.

55. It is evident that limitation of discretion can go

only step by step with adaptation of conditions, and that every one must be allowed full discretion to deal with the unadapted conditions with which he comes in contact. In dealing with these he must nevertheless be efficient. This must be accomplished by the application of Instruction.

When it comes to pulling out the inefficiencies, Adaptations and Instruction are the two jaws of the forceps to do the job. Adaptation must be set up as far as it will go, but it reaches its limits. Instruction must then close up on the inefficiency from the other side until it is firmly grasped and can be pulled out. This is more fully discussed in Articles 230, 231, and 241 to 250.

56. Whatever may be done by the application of the Principles of Efficiency or by any other means, we can not put a machine at the head of a human organization. That place must be filled by a real man.

A certain great industrial organization has operated on less than half of its gross revenue, while about seventy-five per cent is considered the standard ratio in its line of business. I have never met a man more respected by his organization than its manager. His immediate "limited number of subordinate commanders" unhesitatingly proclaim him as the prime mover of everything good that has been done in their departments. He has a committee on safety in whose work he is greatly interested and to which he gives much personal attention. His industry is hazardous, but the comparative safety of his employees is so well known that he has a waiting list of applicants from among the most desirable employees of his competitors. Through a welfare department he provides the means by which his men may be comfortably housed off duty,

as well as kept safe when on duty. For these things he is loved throughout the rank and file of his organization. The newspapers not long ago reported that he had summarily discharged several hundred employees of all grades for violation of his orders to abstain from alcoholic drinks, both on and off duty. Evidently he can, when necessary, make himself feared also. He is, in fact, respected, loved, and feared.

These three things, respect, love, and fear, a superior must win from his subordinates if he is to be in the highest degree successful. Many men command others with considerable success, while comparatively few are loved; but no one ever attained supreme distinction as a leader and commander of men who did not make himself loved as well as feared and respected.

57. Referring again to the analysis of Foster's statement of the Chain of Command, we have still to consider the subordinate commanders and privates.

As to the former, each one is a chief to those below him, and we can therefore transfer what has been said above about the chief down successive grades and apply it to successive subordinate commanders in turn.

As to all the subordinates, there is another matter of supreme importance—team work. Under Ideals (Article 28) and under Personnel (Article 36) I quoted from military writers on this subject. Another quotation from Knox is here in point. With particular reference to the Navy, he says:

> To exercise their command function properly the officer corps as a body must act unitedly. As a preparation to do this they must be educated in the art of war and trained in its conduct. They must be loyal to their Commander-in-Chief and his plans, and must possess a deep understanding of the mind of their common chief and of each other.

In an unsigned article in the *Edinburgh Review* of April, 1911, the statement is made that a sound, comprehensive, all-pervading doctrine (here used in a technical military sense roughly equivalent to "spirit of team work") of war is as important to an army as its organization. This is true to an even greater extent for a navy.

To many officers doctrines are synonymous with principles; to others, the word suggests methods, and still others confound it with rules. While all of these are somewhat related, none of them may properly be considered as having the same military meaning.

The object of military doctrine is to furnish a basis for prompt and harmonious conduct by the subordinate commanders of a large military force, in accordance with the intentions of the Commander-in-Chief, but without the necessity for referring each decision to superior authority before action is taken. More concisely stated, the object is to provide a foundation for mutual understanding between the various commanders during hostile operations.

It is almost as essential to an industrial organization that there should be mutual understanding among its various members during peaceful operations. The necessary foundation is evidently a "deep (and sympathetic) understanding of the mind of their common chief and of each other."

In order that an athletic team may acquire team work, we recognize that there must be harmonious relations between the different members of the team, and that they must have had experience in working together. The same requirements were brought out in somewhat different terms in the discussion of Personnel in the statements of the needs for scientifically selected and harmonious personnel, and of permanence. The staff, which is discussed below, also has an important part in the development of this team work. (See Article 84.)

When all has been done along these lines, much remains for the chief himself to do which can be done

by him only. If he can and does make himself respected, loved, and feared, his organization has an excellent start toward team work.

58. Admiral Mahan said that a chief can give orders properly only by having a close knowledge of details and then by ignoring them. What he meant was, not that the chief should ignore details, but that he should sum them up into their final resultant, and then give his orders accordingly.

Personal experience of the details, and habits acquired by gradual progress through the grades of authority give the ability to do that, but present conditions continually force upon the man in general management the charge of work of which he has had no personal experience. An engineer rises through grades in which his work has been purely technical, until he becomes works manager and finds himself responsible for an accounting department. A salesman rises to be sales manager, still dealing with problems of selling only; but merit there makes him general manager, and he at once finds himself in authority over manufacturing. Either may go on to be president of the company, and become the superior of its treasurer. Besides this, progress is continually filling in processes and methods behind and beneath a man, which were unknown when he was at that stage of his development, and with which he no longer has time to acquaint himself in detail. The only way to deal with this situation is by being willing to take advice, and not only that, but by seeking it diligently from competent counsel.

What, for example, does the retail druggist know about the confectionery business? Yet competition forces him to be a good deal of a confectioner. If he

has taken time to learn that as a side line, what chance has he of being also an expert window dresser? Yet the appearance of his windows is an important factor in attracting custom. If he has mastered all these things, when did he become an illuminating expert? Yet the public expects the drug store to be brilliantly lighted, and most expensively so if the illumination is not efficient. Here are three choice problems for a man who has probably been brought up as a pharmacist.

59. Forrest Crissey, in an article in the *Saturday Evening Post,* tells how the management of a chain of retail drug stores solves these problems:

> Almost every branch of the business has an expert, developed in its own service, who is a traveling instructor in his particular line. For example, this chain has an expert soda dispenser who is a genius in his own line. As a compounder of fancy drinks he is an artist. The soda trade always demands something new, and this man is able to provide it, to give it an attractive appearance and a catchy name, and to build it of inexpensive materials.
>
> Immediately following his visit to the store will perhaps appear the candy specialist. She happens to be a woman, and is as much a wonder in her way as the soda fountain expert is in his. Practically nothing is done in the candy line about which she is not consulted. Whenever a new store is opened she puts the candy department on its feet and gives it a good start. If the candy department in any store shows signs of weakness, she is immediately sent there to gear it up to higher speed and she seldom fails to do it. How? Not by dealing in glittering generalities and selling a whole lot of the goods herself, but by patiently instructing the candy clerks in every detail of displaying, selling, and caring for candy.
>
> The expert window dresser is another itinerant feature, whose coming is looked forward to by the whole force of every store in the chain. The dressing of a window by this specialist is practically a demonstration of the extent to

which goods may be made to sell themselves, and to call customers into the store, where the clerks may apply to them the painless but effective art of constructive salesmanship.

The big city drug store, for example, must of necessity be something of a spendthrift in the matter of lighting bills. A large part of its business is done during the hours of artificial illumination. By an unwritten law it must be so lavishly lighted as to make a bright blur on the landscape of the street. Consequently, the amount of electrical current consumed by any drug store of the Broadway, New York, type is almost beyond the belief of an average layman.

There was no question in the minds of the executives of the organization under consideration but that its stores ought to be the best lighted of any in America. The chain management takes nothing for granted, however; and, therefore, the general manager sent for the chief illumination expert of a great lamp and fixture concern and arranged with him for a preliminary survey of the lighting system of the chain stores in order to answer two questions: Could the expense of lighting be reduced without reducing its efficiency? Could the stores be better lighted without increasing the light bill? His report was that an expert lighting engineer could so rearrange the whole system as materially to increase its effectiveness and at the same time make a decided and permanent reduction in its cost.

Such an engineer was engaged, and he overhauled the lighting arrangements of each store and made a blue print of the system, showing each socket, the kind of bulb and the candle power that should be used in it. One copy was, of course, left with the local manager, and the others were filed at headquarters for the use of the management and those entrusted with the enforcement of the new lighting rules. The net result of this adventure in economy, as stated by the official who instigated it, was a saving of about twenty thousand dollars in the first year of its operation.

Many elements entered into this economy that helped to swell it to sensational proportions. A more economical type of lamp or bulb was used, and the light sockets were relocated and rearranged on a plan dictated by the principles of scientific illumination instead of guess work; reflectors, diffusers, and other aids to the highest utilization of light were installed. All this permitted a radical reduction in the candle-power of the lamps used.

The soda dispenser, the candy specialist, the window dresser, and the two illuminating engineers are all examples of staff; the first three, of regular or organized staff, and the last two of what, in these articles, will be called casual staff.

60. Organization ought, in fact, to be divided into two parts, line and staff. Those people who are directly engaged in the production of results are usually organized as line, the staff is auxiliary. In the oldest organized human activity, infantry, cavalry, artillery, and the aviation corps are line; the rest of an army is staff. In industry three divisions of line are recognized, finance, sales, and manufacture; and the rest is staff. Particular activities are sometimes difficult to assign, but the outline classification holds good.

61. Industrial managers have been especially reluctant to recognize the need of an efficiency staff, and have commonly held that it was wholly the duty of the line to secure efficiency. There can indeed be no efficiency without the co-operation of the line, but neither can the line alone give it adequate attention. Such examples of close analytical studies as are given in the time studies in Article 166 and in Chapter X are alone enough to show that betterment requires a minute attention to details which the line, burdened as it is with responsibility for continuous production, cannot give. Also the duties are inconsistent with each other. One can not concentrate all his powers on the minute study of details and, at the same time, retain that wide view of the field which is necessary to a line commander.

62. When the candy specialist is visiting a store, whose orders are the candy clerks at the counter to obey—the regular manager's, or the specialist's?

Before answering this question, let it be remembered

that any division of authority and of responsibility is a very serious defect in organization.

Evidently unity of authority and responsibility can be maintained only by having the store manager retain his full control. This is an example of the fact that authority belongs to the line.

How then is the candy specialist to accomplish results? In Crissey's own words, "by patiently *instructing* the candy clerks." The function of the staff is, then, to instruct; and, in order to do this, it must have knowledge, which is as distinctively the attribute of the staff as authority is of the line.

Suppose that the store manager resents the presence of the candy specialist as an intrusion. Suppose he uses his authority to thwart her in every way. Suppose he even orders her out of the store. The staff functionary should obey. Strong organization requires, as stated by Major Hine,[1] reorganizer of the Harriman lines, that all lines of authority should be brought together in one person as low down in the organization as possible. This person, foreman, subforeman, or straw boss, alone gives orders to the workers under him, and he alone is immediately responsible for their work. On the one hand no one can dispute his authority, and on the other hand he can not evade his responsibility.

The only proper way to give the candy specialist authority over the local candy clerks is to make her temporarily an intermediate link in the chain of command between them and the manager of the store and thus, for the time being, a member of the line.

As a consequence of giving full authority to the line,

[1] "Principles of Organization," by Charles Delano Hine; The Engineering Magazine Co.

it must also assume full responsibility. The store manager, and not the candy specialist, should be held responsible for keeping the candy business of the store up to the proper Standard. If he is strictly held to full responsibility, either he will welcome all the help he can get from every staff expert that is sent to his store, or he will soon be displaced for failure to meet the standards. However, to avoid delay for such automatic action, the staff should have complete freedom to appeal to higher authority. Any staff functionary whose advice is not heeded by the line should satisfy himself as to whether that inattention was justified; and if satisfied that it was not, should carry an appeal all the way up to the board of directors, if necessary.

The line may be perfectly justified in disregarding staff advice, even though that advice in itself may be perfectly correct. The staff member, being a specialist, necessarily has a specialist's limited view of the situation. The line, from its wider view, may see that the staff advice, though good in itself, is incompatible with the general situation. In such a case, the reason for rejecting the advice ought to be explained and the staff ought to be satisfied.

63. Harrington Emerson tells the story of a department foreman and his staff planner, who were always quarreling and complaining of each other. To put a stop to this, the two men were interchanged. The new planner, with a great appreciation of the foreman's troubles, always tried to plan to make things easier for the foreman; while the new foreman, knowing full well how hard it was to plan efficiently, made every effort to carry out the plans.

This scheme is a regular feature of the United States Army, in which, as far as possible, officers are detailed

back and forth between staff and line duty. It evidently soon finds its limits in the personal fitness of individuals for different kinds of work, but in so far as it is applicable it is very effective in reducing friction between line and staff.

64. In applying these generalizations, full use must always be made of Higher Common Sense. For example: As a general principle, the staff is without authority; but no competent staff will lack the authority that comes from knowledge. The captain of a ship at sea is as perfect an example of full and undisputed line authority as exists. Even the owner, if abroad and at sea, must obey the captain. Yet the ship's doctor, a member of the staff, has in one respect an authority exceeding even that of the captain, in that he can at any time deprive the latter of his command by declaring him incapacitated; but if the doctor should do this, authority would remain in the line, passing unimpaired to the next subordinate line officer.

65. At best co-operation between the staff and the line is no easy matter; and this emphasizes the necessity for the selection of a harmonious personnel and team work pointed out in the chapter on Personnel.

Evidently, organization has a soul as well as a body, and all attempts to build up the body without animating it with a soul leaves it only a dead and useless thing.

The soul of an organization is its spirit of team work, known to military men as "doctrine," which has already entered into this discussion. Lieutenant Commander Knox, writing of this subject with particular reference to the United States Navy, says that the first and most essential step in indoctrinating a military service so as to assure co-ordinate action during hos-

tilities, is to formulate a "concrete, comprehensive, and coherent conception of modern war." Paraphrased into terms of efficiency principles, this means that the head of the organization shall adopt for himself correct Ideals and shall inspire his subordinates with them and with subsidiary Ideals consistent with them. A re-reading of the chapter on Ideals will be useful at this point.

66. Turning again to the body of Organization, as a knowledge of anatomy is valuable it may be well to sketch its structure. This is shown in Figure 1. It must be remembered that organization is subject to so many modifying influences that any diagram of this kind, unless closely limited to some particular case, must be regarded as suggestive only.

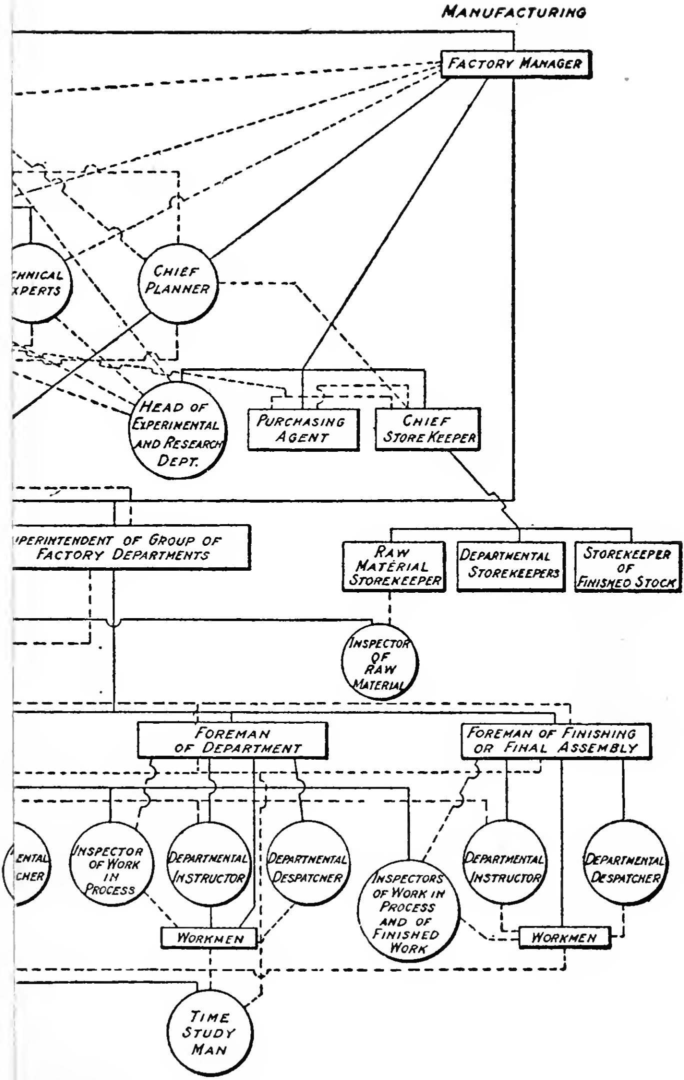
In the diagram, line functions are shown by rectangles and staff functions by circles. Line authority from every person to his next lower in authority in a chain of command is shown by a full line. All relations from which authority is lacking are shown by broken lines. For example, Figure 1 shows with reference to the Factory Manager:

That he is a line officer;

That his next line superior in the chain of command is the President, or General Manager, who is the only person having authority to give him orders which he is required to obey;

That the persons next lower in authority to him in the chain of command are the Purchasing Agent, the Factory Superintendents, the Chief Planner, the Chief Store-keeper, and the Head of the Experimental and Research Department, *to whom alone he should issue his orders;*

That he is advised, as his immediate personal


MANUFACTURING
FACTORY MANAGER
...HNICAL ...XPERTS
CHIEF PLANNER
HEAD OF EXPERIMENTAL AND RESEARCH DEPT.
PURCHASING AGENT
CHIEF STORE KEEPER
...PERINTENDENT OF GROUP OF FACTORY DEPARTMENTS
RAW MATERIAL STOREKEEPER
DEPARTMENTAL STOREKEEPERS
STOREKEEPER OF FINISHED STOCK
INSPECTOR OF RAW MATERIAL
FOREMAN OF DEPARTMENT
FOREMAN OF FINISHING OR FINAL ASSEMBLY
...ENTAL ...CHER
INSPECTOR OF WORK IN PROCESS
DEPARTMENTAL INSTRUCTOR
DEPARTMENTAL DESPATCHER
INSPECTORS OF WORK IN PROCESS AND OF FINISHED WORK
DEPARTMENTAL INSTRUCTOR
DEPARTMENTAL DESPATCHER
WORKMEN
WORKMEN
TIME STUDY MAN

staff, by the Chief of Staff, by the Technical Experts, by the Head of Department of Standards, and by the Employment Supervisor.

67. In the main, the diagram of Figure 1 is self-explanatory, but some discussion may make it plainer. In so far as possible the chain of command is worked through the line only. This often results in putting some staff functionary in a chain of command as a direct subordinate to some member of the line. For example, the Factory Manager must necessarily control the planning for the factory. In order to do this he must have authority to tell the Chief Planner what to plan, and to give such orders with reference to the plans as are consistent with leaving the Chief Planner necessary discretion. The Chief of Staff also exercises some control over the Chief Planner, but his interest is limited to seeing that efficient methods of planning are employed and that the plans finally work out into good shop efficiency. The needs of the Factory Manager require authoritative action and prompt obedience. For this reason the Chain of Command is represented as running from him to the Chief Planner, a staff officer, instead of to the latter from the Chief of Staff, his immediate staff superior.

Similarly, every foreman of a shop department is represented as having a staff consisting of one or more inspectors, an instructor, a time-study man, and a departmental despatcher. Line authority over the instructor and the despatcher is represented as belonging to the foreman instead of to their respective staff superiors. In the case of the departmental despatcher, who is the local member of the planning staff, the reason for this is similar to the reason for placing the Chief Planner under the line authority of the Factory

Manager. The instructor is placed under the foreman, because it is desirable that the foreman should have the authority to tell him whom to instruct and when.

In the case of the inspector, such an arrangement would not be satisfactory. The foreman has considerable interest in having as much of his product passed as possible, and this may be intensified by his Efficiency Reward. To counteract this, it is correct organization to place the departmental inspector under the authority of the Chief Inspector, and to make him advisory only to the foreman.

In some particulars it may be necessary to give the departmental inspector authority exceeding even that of the foreman. The inspector ought always to see a job as soon as possible after work has begun, because it is even more important for him to prevent damage than it is for him to reject defective product. I have had one case in which, in order to enable an inspector to accomplish the first purpose, I had to obtain from the management authority for the inspector absolutely to order a shut down of any operation which he saw to be producing excessive damage. In such a case, the set-up for the job had to be gone over and corrected before the foreman could allow it to continue.

68. It is only in very rare and exceptional cases that the staff has authority over the line, but there are several chains of command which run from superior in the staff to subordinate in the staff, the superior having full line authority over the subordinate. For example, the Chief of Staff is responsible for seeing that the Chief Inspector has correct specifications, that he has proper equipment for making the necessary tests, and that his department uses correct testing methods. The line officers whose work the inspection

department directly touches, the Purchasing Agent, the Chief Store-keeper, and the Superintendents of factory departments, are none of them competent to do anything more about inspection than to advise in the drawing of specifications; therefore the Chief Inspector is represented as standing in only an advisory relation to them, and as being under the full line authority of the Chief of Staff.

69. Wherever efficiency can be increased by cutting the corners of the channels of authority shown on the diagram, that should be done in ordinary routine. For example: The diagram indicates that the Store-keeper of finished stock on finding his stock of any article running low will make a requisition for a new supply and forward it to the Chief Store-keeper. The latter, if he approves, will sign the requisition and forward it to the Factory Manager. The latter, if he approves, will order the requisition filled, and forward it to the Chief Planner.

The latter will analyze the requisition as to factory departments and distribute these divisions of the requisition among the subordinate planners of the Central Planning Office for them to work out the necessary orders to the factory. The subordinates will return these orders to the Chief Planner who, if he approves them, will forward them to the Factory Manager. The latter, if he approves, will forward them to the Factory Superintendents concerned, who will forward them to the respective Foremen.

In the above procedure, the Superintendents are mere conduits. As to the Factory Manager, the Chief Store-keeper, and the Chief Planner, they can not intelligently approve or disapprove the matters thus put up to them by their subordinates unless they burden

themselves with detail work of which it is intended that these very subordinates should relieve them. As it is physically impossible for these superiors to do the detail work, in actual practice they merely rubber-stamp the orders and requisitions, and eventually turn even that operation over to a clerk. The next step in degeneration is for the clerk to take upon himself the actual judgment and discretion over matters on which he is entirely incompetent to pass.

It is, of course, necessary that the chiefs above mentioned should have authority to *disapprove* at any time any action of their subordinates, and that they should have the power of initiative in matters which the regular routine may not have caused their subordinates to start. Therefore the lines of authority have to run as shown in the diagram; but in actual practice red tape is cut out and procedure is made more efficient if the Store-keeper of Finished Stock sends his requisitions directly to the Chief Planner, who divides the work among the subordinate planners of the Central Planning Office, and they prepare the manufacturing orders and send them directly to the Foremen concerned.

70. For any particular case, the diagram may be incomplete. For instance, in some or all departments, it may be necessary for the Head of the Department of Standards to have both a Time-Study Man and also a Material-Study Man.

71. There should be full freedom of consultation by everybody in the organization with everybody else who can give him information of value—within the limits of Common Sense, of course. We should not, for example, expect one of the workmen to go to the President for advice or instruction. It would be impossible

to represent this freedom of consultation on the chart; so all that can be said is that nothing on the diagram should be taken as limiting it in any way.

72. It is impossible in a diagram of a general character to mention in detail even some offices which commonly exist. For example, the Master Mechanic may be considered as being represented on the diagram by one of the Superintendents, and the Mill-wright by one of the latter's Foremen. The Chief Engineer, similarly, may be considered as being one of the Technical Experts of the diagram.

73. For any particular case, the diagram may be excessive—an Experimental and Research department is comparatively rare, rarer than it ought to be.

74. For any particular case, it may be necessary to modify the diagram. For example, it may be necessary, in order to give some foreman enough control over his materials, to make the Store-keeper of that department a line subordinate to its Foreman, instead of to the Chief Store-keeper. If this were done, the Foreman would draw his supplies in large quantities for his store-room on requisition and the Chief Store-keeper would be credited with them. They would then pass to the departmental store-room and the Foreman would become responsible for them.

Another common modification is to make the Chief Engineer the head of all the Technical Experts, and to place the Experimental and Research Department under him. This department is commonly modified into a Department of Design and Tests.

75. Theoretical organization is also modified, often greatly so, by the application of the principle of Personnel. A Financial Manager may have peculiar aptitude along some scientific line connected with the in-

dustry, and, in order to make full use of this, it may be necessary to tolerate anomalous relations between Finance and the Experimental and Research Department. We may have in one department a foreman who is a good executive, but only a passable mechanic and not adapted to teach his men. We shall have to place in his department strong staff representatives of inspection and instruction, while it may be possible to leave departmental planning largely to the foreman's personal ability. Elsewhere we may have a foreman who is highly skilled in his art and is an excellent teacher, but lacks executive ability. If his department is not too large, he may be his own inspector and instructor, but he will need the support of a strong planning staff.

The Army, the Navy, and the Roman Church have organizations which are almost independent of personal considerations; but in order to operate these organizations successfully, they have to catch their Personnel young and plastic, and minimize personal differences by moulding it in an iron Discipline. Until industry can do the same thing, it will have to make considerable concessions to Personnel in applying the principle of Organization.

On the other hand, many industrial organizations have conceded entirely too much to personality. They are, in fact, merely natural growths which have followed always the lines of least resistence at the moment, with little or no regard for correct organization. Many inefficiencies have been introduced in this way which can be eliminated by correcting the organization.

However, the case is one of conflicting requirements like many others which are familiar to the engineer,

and, as in all such cases, the proper solution is to make the best possible working compromise.

76. The diagram, Figure 1, deals with functions. In any actual organization as many of these may be undertaken by one individual as his time and ability will allow. In a small organization this may be a good many. In a small plant, the functions of the Chief Store-keeper and of all the subordinate store-keepers may be discharged by one man. In a still smaller organization, he may be Purchasing Agent as well.

Again, one man may be both Inspector of Raw Materials, a member of the staff inspection corps headed by the Chief Inspector, and also Material-Study Man, coming under the Head of Department of Standards.

77. As shown by the diagram, this functionary as Inspector of Raw Material is also staff to the Raw Material Store-keeper.

Where an individual thus owes a divided allegiance it is necessary clearly to differentiate his functions and to define the authority over each one. If this can be done and, still better, if the times when he is occupied in any one function can be clearly set off from all the others, no conflict of authority or division of responsibility need arise from this situation.

Unity of authority and responsibility is nowhere more insisted upon than aboard a man-of-war, and no organization is more efficient; but the enlisted man in the Navy comes under one officer when on watch, under another when at his battle station, and under a third when on boat duty. But there is never any doubt as to what officer has authority over him and is responsible for him at any particular time.

In the staff, these cases of divided allegiance are very common, as a study of Figure 1 will show. Take,

for example, the case of the individual who is supposed to be both Inspector of Raw Materials and Material Study Man. The Raw Material Store-keeper tells him what to inspect and when, the Chief Inspector tells him how to inspect, and the Head of Department of Standards requires from him reports of data on which to base standards of materials.

We have here a case of *functional control.* It is a form of "division of labor," or specialization, and as such makes for higher efficiency; but it endangers one of the fundamental principles of Organization, unity of authority and responsibility. This danger must be guarded against, as above explained, if functional control is to be employed with efficient results. It is therefore best to organize as far as possible, so as to have in the line, which is immediately responsible for producing results, unity of control assisted by staff advice, and to throw all functional control into the staff where friction does not so vitally affect immediate results.

78. While it is the distinguishing function of the staff to advise the line, staff officers may be advised by other staff officers and by line officers as well. For example, the Chief Inspector, a member of the staff, not only advises and is advised by the Technical Experts, the Head of the Department of Standards, and the Employment Supervisor, staff officers, but also advises and is advised by the Purchasing Agent, the Chief Store-keeper, and the Superintendents, line officers. In order to enable these people to deal harmoniously with matters of inspection, it is well to bring them all, except the Employment Supervisor, together into an organized committee. This question of committees is discussed further in Article 83.

79. Some features of the Diagram of Organization—for example, the planning organization—will be best understood if Figure 1 is consulted in connection with the discussion of those principles of efficiency with which they are immediately concerned.

80. Suddenly to make over the organization of many operating concerns into any theoretically correct form, would be like cutting a man open and at once performing on him several serious operations of abdominal surgery. They might all be needed to restore him to health, but if they were all performed at once, he would probably die of shock. The surgeon has to proceed more gently—prepare the patient, and then perform one operation at a time with proper periods of convalescence and rest between. Similarly, the proper way to correct an organization would usually be to design that organization carefully and to record the design in permanent form, and then gradually to make over the organization from the existing to the desired form.

81. Many concerns do not clearly understand what their organization *is,* to say nothing of what it ought to be. This ignorance always leads to internal friction and inefficiency. There can be no question that every concern ought to work out an analysis of its existing organization and to have it thoroughly understood, at least by all the officers of the company. On this point Kimball[1] says:

> It is not good policy to keep men in uncertainty of their position in the organization, and when several men are on the same authoritative level their several fields should be carefully prescribed and their efforts carefully co-ordinated. This is particularly true when a considerable amount of staff

[1] Dexter S. Kimball, Principles of Industrial Organization. McGraw-Hill Book Co.

organization is introduced, since this tends naturally to weaken the disciplinary effects of line control; and where staff organization is used to any marked degree special care must be used to supply co-ordinative influences to compensate for this weakness.

While a certain amount of co-ordination can be accomplished by personal influence, it is obvious that, where large numbers of men are involved, or where preplanning of the work is necessary, written documents must be resorted to. For instance, an authoritative diagram facilitates a clear understanding of the relations between the several officers and departments. In some cases the detail duties and authority of men and departments are issued in written form and copies of these instructions are bound up into an organization record that serves as a permanent record of the organization. Whether such a volume is necessary or not, the duties of men and departments should be issued in writing, and necessary adjustments between men made by some one higher up, and not allowed to remain a constant source of irritation and dispute. The specifying of the duties of the several men has the added advantage of compelling the organizer to think out his plan of organization with the same care that the designer of a machine bestows upon the several parts to insure smooth running.

One of the things which is most apt to require immediate attention in any improvement of Organization is the relief of executives from routine and clerical duties that can just as well be done by cheaper men, in order that they may have time to use their brains effectively in the discharge of their own proper duties. This is especially apt to be true of shop foremen. It is no uncommon thing to find them slaving at their desks, writing orders, recording production, and making out reports, all of which could be better done by a good clerk, while their departments are suffering from lack of their attention. This is an example of the fallacy that low ratio of overhead to direct cost is an indication of efficiency, and of the fact that this fallacy is an actual obstacle to efficiency. The em-

ployer, holding to this fallacy, not only thinks that he is saving the wages of a clerk, but that he is increasing his efficiency by so doing. On the contrary, he is paying most extravagantly for the clerical work and is also undermining the efficiency of the department, for, while the foreman's nose is buried in the papers on his desk, his department will be found operating at gross inefficiency, and parts of it may be actually idle and out of work from sheer inability of the foreman to get around and tell the men what to do. This sort of thing is not the fault of the official immediately concerned, but of those higher up who, from false ideas of economy, make it impossible for him to do his work well.

Adequate staff organization is one of the best means of relieving executives of the burden of details. Thus, in Figure 1, the Factory Manager is represented as being relieved of burning the midnight oil to dig out for himself required technical knowledge, by the expert advice of the Chief of Staff, the Head of the Experimental and Research Department, the Technical Experts, and the Head of the Department of Standards; and as being relieved by the Chief Planner from attention to the details of the progress of orders through the plant. Near the other end of the organization, every foreman is represented as being relieved by members of the staff of the details of employment, inspection, instruction, study of operations and conditions, and despatching of work in progess. This relief to the foreman should, of course, be made either more or less, according to circumstances. Its object is to enable him to give adequate general attention to his whole department by not having to concentrate his personal attention long on any detail.

82. In the above, the Head of the Experimental and Research Department and the Technical Experts are considered as reaching out into the fields of knowledge and bringing to the line an acquaintance with the laws of Nature, which it could not have otherwise; and the other members of the staff are represented as doing this and also as bringing to bear upon the details of operations within the plant a closeness of attention which it would be impossible for the line alone to give it.

The latter aspect of the work of the staff is closely analogous to that of the sympathetic nervous system in the body, of which Van Deventer says:

> It is evident that the less those who plan and execute are concerned with strictly routine matters, the more effectively will the work be done. So important is this principle, that the Great Designer saw fit to organize a distinct branch of management to take care of the routine. So that, without thought, the heart beats, we breathe, the digestive and other vital organs perform their functions. Think of the burden that would be thrown on the general manager (the cerebrum) and the action department (the cerebellum) if the routine department (the sympathetic nervous system) did not exist. If these thousands of simultaneous efforts required conscious thought and planning, what time would there remain in which to think about science or art or literature or new inventions?

83. With reference to the amount of staff shown in Figure 1, the manager of a small organization should remember that the diagram represents functions; and it may well be that a careful re-design of the organization will result in so much increase of the efficiency of individuals that one person may fulfil several of the functions shown. For example, a line head of department may be able to be staff adviser to the rest of the organization in matters of his own specialty.

In a certain works the sale of the product is very dependent upon its appearance. It was indicated above that design would be placed either in the Experimental and Research Department, or under one of the Technical Experts. In this case, due to the great effect of design upon sales, a justifiable modification is made by placing design under the Assistant Sales Manager, but he can not be expected to know its effect upon factory efficiency. The superintendent of the factory, the master mechanic, and the efficiency engineer, all from different angles, have knowledge of the latter. All four of these officials are therefore brought together in a Committee on Design. In this case, the committee exercises staff functions only. It can advise the assistant sales manager, but the authority over and responsibility for designs rests with him only. Any other member of the committee, however, has full right of appeal from his decisions to higher authority.

Whether a committee should be staff to one or all of its members, or whether it should have line authority over any or all of them, is a matter of expediency in every case. Before giving a committee line authority, it must be seen that no chain of command will be broken, and that authority and responsibility will not be weakened or divided.

Further relief from excessive staff personnel may be obtained by the use of what is above called "casual staff." Casual staff members may be only temporary —for example, there is the consulting expert, who may be called in when his services are required.

A great deal of competent counsel may be obtained from Government and other bulletins and from technical publications. The practice of one of the two most efficient industrial organizations with which I have

ever come into contact is of interest in this connection. As I shall have to speak of this organization several times, I shall for convenience call it the X. Y. Z. Company. It took a large number of technical publications. Every one of them on arrival was gone over and interesting matter was marked, "Attention of Mr. Blank." The publication was then circulated through the organization, and every member was expected to study matter marked for his attention.

There is also a usually unworked mine of competent counsel in the members of the organization from the top to the bottom. In the X. Y. Z. Company, several monthly cash prizes were offered for the best suggestions, and everybody in the organization was encouraged to offer them. If anyone of the grade of foreman or higher failed for any considerable time to make a suggestion, this encouragement took the form of a sharp inquiry as to whether he had gone to sleep.

Complaints are a form of suggestion and may often contain matter of value. The chronic kicker ought to be suppressed, but complaints from other sources should have prompt and fair attention. The Employment Supervisor furnishes a proper channel through which this can be given without burdening the line.

Exchange of ideas with others is also a valuable source of competent counsel. Associations of persons having the same interests, like the engineering and technical societies, furnish a convenient medium for this exchange.

Added to the above is the salesman, who carries ideas about as the honey bee carries fertilizing pollen from one flower to another. The practice by some concerns of having definite office hours during which some officer of the company receives salesmen and gives

careful attention to what they have to say is worthy of imitation.

84. Military writers recognize that it is one of the functions of the staff to develop that spirit of team work, which they call "doctrine." It is important to see whether the staff has the same important function in industry. Analyzing the statements which have been made in reference to military "doctrine," where that subject has already come up, under Ideals (Article 28), Personnel (Article 36), and Organization (Article 57), it appears that its development is dependent upon ideals, instruction, discipline, fair deal, permanence of personnel, co-ordination and co-operation, records, efficiency reward, standards, and higher common sense. Referring to Figure 1 and the preceding discussion, it appears that instruction is dependent upon the Chief Instructor; discipline, fair deal and permanence of personnel, very largely upon the Employment Supervisor; co-ordination and co-operation, upon the Planning Department (and it will appear when planning is taken up that records and efficiency reward also depend very largely upon that department); and standards are dependent upon the Head of Department of Standards. All of these functionaries are members of the staff, and higher common sense is peculiarly the affair of the staff as a whole. As the line also comes in on all these matters, we should not lay the responsibility for the development of team work in industry entirely upon the staff; but certainly it has such an important part to play in it, that proper team work must be impossible to obtain in any organization in which adequate provision is not made for the discharge of staff functions.

85. In our industry the line is usually much better

developed than the staff; and it is therefore necessary in this discussion to lay great emphasis upon the staff, but, in so doing, we must not forget the importance of the line.

Good line organization is above all effective in dealing with unforeseen and unadapted conditions. In such a situation it is like the human hand, in that it is able to wrap itself about the oddest shapes and to handle them powerfully. Police quelling a riot, firemen extinguishing a blaze, and soldiers in battle are examples of the ability of good line organization to deal with emergencies; and it is in those organizations which deal most with emergencies that we find the most highly developed line.

To take away the line entirely is to deprive organization of its ability to deal with unforeseen and unadapted conditions. It is to deprive it of its backbone, the Chain of Command, and render it invertebrate.

Chapter VII

RECORDS—PLANNING AND DESPATCHING

INTRODUCTORY MEASURES

86.

IN the theory of efficiency, Records and Planning and Despatching are two separate principles, but in practical application they are Siamese twins which can not be cut apart without killing them both.

Discussions of these two principles are apt to leave one with the feeling that his own needs have not been met. This results from the fact that their application has to connect so closely with the practical details of the work that any discussion is apt to deal so exclusively with some assumed or actual case that it has very little application to any other, or else to run to the opposite extreme and be composed of such generalities that it is very difficult to apply it to anything.

These two principles are like swimming, in that they can be learned only in doing the actual thing. However, no greater service can be rendered to a boy who is learning to swim, than to teach him to get down into the water up to his nose and let it support him. When he has mustered courage to do that, he finds that the water bears him with practically no effort on his part, and that the stroke is of only secondary importance.

So it may be of service to indicate to the manager some principles of Records, and of Planning and Despatching. If he will apply them and will get after his planning, despatching, and records with determination, he will find that the particular methods and forms that he uses in carrying out these principles are of only secondary importance.

As to forms, there is about one chance in a million that any one form can be transferred from any plant to another without re-designing it. In these articles it is therefore put squarely up to the efficiency practitioner to design his own forms. Such discussion as may help him in so doing is given; and illustrative examples, not models, are given of a few forms which require only minor modifications in adapting them through a wide range.

87. Planning is necessary for three purposes:

To prepare in advance for what is to be done;

To co-ordinate all lines of activity so that they work together to achieve the common Ideal, and

To concentrate all available force upon the work in hand.

Despatching is guiding the execution of the plans.

The provision of necessary material and personnel requires advance preparation, which must be planned.

The co-ordination of separate activities requires each to be designed to fit in with every other; that is, that they be planned.

In order to focus the available force upon the work in hand, the management must be sure that no other work is being neglected. It can have this assurance only by providing for every item of work its time and place for sufficient attention, and this can be done only by planning time and place for all the work.

88. It is evident that any failure to accomplish any of the three purposes above stated must lead to a loss of efficiency. It is also evident that work cannot go on unless somebody decides to put certain jobs into work at certain times, with the use of certain men, equipment and materials; and the making of these decisions is at least a rudimentary planning. It is further evident that any improvement that can be made in this rudimentary planning will at once increase the efficiency. It is therefore possible very early in betterment work to make financial gains by improving the planning, and this marks planning as one of the first matters for attention.

89. On the other hand, if it is suddenly discovered that the plant is out of some needed article of stores, plans are upset. If workers are continually leaving, and new ones have to be taken on in their places, the uncertain and unskilled labor of green hands disarranges the plans. In short, every inefficiency in the plant interferes with planning. Hence, planning can not be perfected until every other principle of efficiency has had its full application.

90. On the one hand, the importance of planning and the possibility of early gains by improving it mark it as one of the earliest steps of betterment; on the other hand, its dependence upon every other measure of betterment shows that it is impossible to introduce well developed planning at the outset, and that its development can only go step by step with other improvements, and that advantage ought to be taken of every other improvement to make some gain in planning.

91. The immediate question is how to make an early start at planning. This is dependent upon the

existing state of planning, and therefore is different in every case, but a few fundamental principles will always apply.

The Ideal in planning is to obtain a coincidence of certain events as to time, and sometimes as to place.

Suppose an order is about to go to a group of departments, 1, 2 and 3, for an article composed of parts A, B, and C. Department 1 makes parts A and B. Department 2 makes part C. Department 3 assembles A, B, and C into the finished article. The superintendent of the three departments knows when he wants the finished article. The foreman of Department 3 knows in about what time he can assemble it. Similarly, the foremen of Departments 1 and 2 know roughly how long it will take their departments to make the parts required of them. The four men have among them the knowledge, though probably only to a rough approximation, that is necessary to plan the main outlines of the progress of this order through the three departments. If they are brought together, the superintendent can state when he wants the article; the foreman of the Assembly Department can state when he wants the parts; the foremen of Departments 1 and 2 can state the possibilities of their departments; then the superintendent and the other foremen can adjust their requirements accordingly until a definite program is agreed upon. Hence, usually one of the first steps necessary in order to get some kind of crude planning going is to get the line officers immediately concerned together at regular and frequent intervals in a planning meeting, and to have them therein determine departmental delivery dates of the shop orders.

Such a planning meeting has not only to lay out approximate departmental and final delivery dates for

every order, but also to revise the program from time to time and to enforce it. In order that it may accomplish these purposes, some kind of systematic aid to the memories of the members of the committee must be installed. In the probably chaotic state of things in which this much of an improvement in the planning is started, some form of tickler file is very well adapted to the purpose. Suppose that the meeting works out the program for the supposed order as follows:

Final delivery	Sept. 30
Assembly	days 3
Deliver parts to Department 3	Sept. 27
To make part B	days 5
	Sept. 22
Sunday, Sept. 24th	day 1
Department 1 to start B	Sept. 21
To make part C	days 8
	Sept. 19
Sunday, Sept. 24th	day 1
Department 2 to start C	Sept. 18
To make part A	days 12
	Sept. 15
Sundays, Sept. 17th and 24th	days 2
Department 1 to start A	Sept. 13

All that is necessary to get the tickler file going is for the clerk of the planning meeting to write the information as above shown on any convenient card, or on the back of a copy of the job order, and file it under an appropriate date. The probable lack of adaptation of conditions, of standards, of despatching, and of efficiency reward is likely to make it necessary at this stage to revise any such tentative program a good many times before the work is complete.

For the same reason, it is well to bring the program up for preliminary attention and, if necessary, for revision somewhat before the date planned for the occurrence of any event. Supposing that the program is made out on September 1, it would probably be well to file it first under date of September 7. When the planning meeting on that date goes over the tickler file for the day, this card will come to its attention. It would then be in order for the foreman of Department 1 to report whether he expected to be able to start part A as planned, and, if not, to ask for whatever revision of the program might be necessary.

Supposing that he reported that he expected to be able to start on time, the card might then go back into the tickler file for September 12, and would then come up to remind the foreman to start part A on the following day. It might then go into the tickler file under September 15. When it came up on that date, it would call for a report of progress on part A and an inquiry as to the prospects for starting part C according to program, on the eighteenth.

92. Planning is the exercise of foresight, including the continuous revision of distant foresight by later, closer, and clearer vision. Planning needs to be done and done again at every moment; but to make sure of

its being done at all, there should be certain times when, as a matter of routine, work is planned as far ahead as practicable foresight will allow. It is a mere superstition that putting into a plant any particular set of ruled and printed forms can effect any economy; but to make sure of having plans which are at once comprehensible to all concerned and easily expressed by those responsible for them, every concern should state its routine plans in some standard ruled and printed form designed for its own needs.

93. All that can be claimed for the crude planning thus far outlined is that—

It increases the probability of delivering the finished article on the desired date;

It causes the manufacturing departments to lay out their work so as to meet the needs of the assembly department;

It causes the work to be done in the order in which it is needed, instead of solely as it may be locally convenient to the men and machines concerned.

Nevertheless, even these may be valuable gains over the previous state of affairs.

94. It is to be noted that the planning committee's program fulfils the requirements of an order, as stated in the chapter on Organization, in that it leaves the foremen discretion corresponding to the general lack of adaptation of conditions in their departments, and to that discretion it sets limits within which it requires them to work.

95. In starting Planning, it is not us ally possible to take up orders which are already in the plant. It will probably be necessary to take up only new ones as they are issued, and to allow those already in the shop to work themselves out by former methods.

SERVICE CARD No.				DATE	
Dept. No.	Employee			Operation No.	
Start	Cont.	Fin.	Mach. No.	Sched. No.	Order No.
				Operation No.	

Details			
	Standard	E	
	Time Finished	W	
	Time Started	B	
	Time Elapsed	H	

1 Alter	7 C. Sink	13 File	19 Grind	25 Oil	31 Repair	37 Shellac	43 Spin	49 Touch Up
2 Anneal	8 Cut	14 Fit	20 Knurl	26 Polish	32 Rivet	38 Size	44 Stamp	50 Trim
3 Assemble	9 Decorate	15 Flatten	21 Lacquer	27 Prepare	33 Rough	39 Slip	45 Straighten	51 Tune
4 Buff	10 Dip	16 Form	22 Lap	28 Press	34 Route	40 Slot	46 String	52 Turn
5 Burnish	11 Drill	17 Gild	23 Make	29 Punch	35 Sand	41 Solder	47 Tap	53 Wash
6 Burr	12 Face	18 Glue	24 Mill	30 Ream	36 Saw	42 Sort	48 Thread	54 Miscell.

FIG. 2. LABOR REQUISITION OR SERVICE CARD

96. In order to help the foremen to fulfil the delivery dates required by the program, the rudiments of Despatching ought to be got under way in their departments as soon as possible. There is a form of Record which is so useful in this connection, which serves so many other purposes as well, and at the same time so economizes clerical work, that it ought to be explained at this point.

The problem, in connection with every operation in the shop, is to get in one job of clerical work an immediate, adequate and reliable record of every item of information that is wanted, and to furnish every one needing records of that operation with the information that he needs. The first question then is, Who needs information about the operation? The next, with reference to each of these, What information does he need? The answer to the second question assembles a statement of all the items which it is necessary to record. By recording the facts as to all of these on one form we get them all in one job of clerical work. The number of different persons who need the information determines the number of copies that must be made of the record; and by having these copies padded together and by placing carbon paper between the sheets, the clerk makes all of them at one writing. Three good legible copies may be easily made in this way and are usually enough, but five can be made by having the records on carbon-backed paper instead of inserting carbon sheets.

To make the thing clearer, I illustrate by an example. (See Figure 2.)

Ordinarily the persons who need records direct from operations in the shop are the paymaster, the cost accountant, and the planner.

We may conveniently arrange in tabular form the information wanted by each of these, as shown by Figure 2.

TABLE 1.

DATA WANTED FROM LABOR REQUISITION, OR SERVICE CARD

By Paymaster	By Cost Accountant	By Planner
Date Department Employee	Date Department	Date Department Employee
Whether job is started, continued, or finished	Whether job is started, continued, or finished	Whether job is started, continued, or finished The machine used The schedule number [3]
	The order number The operation	The order number The operation
The standard time of the operation	The standard time of the operation	The standard time of the operation When work began ("Time Started") When work ended ("Time Finished")
Time elapsed on the work	Time elapsed on the work Equipment rate, or hourly cost of running the machine used (E) [1]	Time elapsed on the work
Wage per man-hour (W)	Wage per man-hour (W) [1] The hourly burden (B) [1] Man-hours of labor on the job (H) [2]	
Special information in particular cases, included under "Details"	Special information in particular cases, included under "Details"	Special information in particular cases, included under "Details"

In this case all the operations performed in the department are listed at the bottom of the card and numbered; and "Operation No." in the fourth line of the card is filled in by number only. This is convenient

[1] $\Sigma\{(W + B + E) \times (\text{Time elapsed})\}$ = Total cost. In the case of a gang operation this has to be summed up from all the cards of the gang, or the despatcher has to summarize this on the card of the gang boss.

[2] As to (H) see Article 103.

[3] An example of a schedule is given in Table 3, Article 108.

in the use of the card; but if any considerable amount of time will be required to prepare the numbered list of operations, it will be better to get the cards into use without it, and to denote the operations by the names by which they are commonly known in the shop. However, operations should be given some definite designation as soon as that can be done without delaying more important work.

Wage per man-hour multiplied by "Time Elapsed" gives the paymaster and the cost accountant the direct wages on the job; "Standard" divided by "Time Elapsed" gives them the efficiency. If a system of bonus payment dependent on the efficiency is used, the latter by reference to a bonus table gives them the per cent of bonus.

The direct wages multiplied by the per cent of bonus gives the bonus due on the job.

The information wanted will, of course, vary according to local conditions. Other information commonly wanted from the service cards is given in Table 2.

TABLE 2.

OTHER DATA COMMONLY WANTED FROM LABOR REQUISITIONS OR SERVICE CARDS

By Paymaster	By Cost Accountant	By Planner
	The article or part in work	The article or part in work
		Amount ordered
	Number of pieces completed:— Brought forward from previous cards; On this card; Total	Number of pieces completed:— Brought forward from previous cards; On this card; Total
		Responsible inspector
Other workers employed simultaneously in case of gang operations	Other workers employed simultaneously in case of gang operations	Other workers employed simultaneously in case of gang operations

Tables 1 and 2 are not offered as exhaustive in all cases. The proper procedure is to list the information wanted, as is done in those tables, being careful to call for only needed information, and then to design a form to contain it.

Supposing, as is commonly the case, that only the Paymaster, the Cost Accountant, and the Planner need reports; three copies are enough. Three sets of file records originate from the three copies of these cards; and for the sake of distinction between the files and of uniformity in each of them, it is convenient to make each of the three copies on paper of a different color. They are then padded in sets, into which the clerk inserts the carbon papers for making all three copies at one writing. In the regular use of the cards, one copy of each will go to a workman as his order to do the job, and will be returned by him as his report that he has ceased work on it. The card for this purpose needs to be rather heavy, and its thickness puts it at the bottom of each set in padding, in order that carbon copies may not have to be made through it.

97. In order that a foreman may be able to plan and despatch the work within his department, he should, unless his department is very small, be given the assistance of a clerk, known as a "despatcher," for that special purpose. As explained in Article 81, the wages of this clerk are a good paying investment, because they come back many times over in increased efficiency of the department.

98. It facilitates the work of the foreman and of the despatcher very much to provide them with a board, called the "despatch board," on which to distribute the jobs to the different workers of the department. This board has been described and illustrated

so many times that I shall say only that it contains two pockets or receptacles for every worker, one of which I shall call the "stand-by" pocket and the other the "reserve" pocket.

The despatcher, with desk and despatch board, should be located in some place easily accessible to the workers. One despatcher can serve about one hundred workers, and may despatch for several foremen.

There should always be a card in the stand-by pocket of the board for the next job that the worker is to do.

When a man stops work on a job, he should deposit the card for it on the despatcher's desk as his notice to the latter that he has ceased work on it, and should take his card for the next job from the stand-by pocket.

This involves the worker's walking to and from the despatch board every time he changes his work. When planning is going right, his jobs ought to be assigned to him in long runs of the same kind of work, as it increases his efficiency to have them that way; and, when this is accomplished, the amount of time that he spends going to and from the despatch board is negligible. Also, it is a mistake to suppose that it increases a man's efficiency to root him to one spot for hours at a time. He needs to stir about once in a while, to stretch his legs, and to relieve the monotony, and his efficiency is increased by so doing. This is discussed further in Articles 206, 208, and 216.

99. It is usually a good plan to begin departmental despatching by setting up the despatch board and having the men report to the despatcher and change their cards with every change of jobs. The despatcher should record these changes on the cards from the men's reports, while at first allowing the workers to receive their orders just as they have done previously

to this time. The purpose of this is to accustom the men to the use of the board, and to teach the despatcher to keep the records. This should be accomplished before anything is made to depend upon the use of the cards.

Where previously the work has been very poorly planned, this may mean at first that the men have to change their cards very often, which is, of course, a nuisance; but this is a condition which needs to exist for only a short time, during which it can be tolerated for the sake of results to follow.

100. As soon as the use of the board has been learned, we can start despatching the work in the department, so as to fulfil the departmental delivery dates set at the planning meeting. The foreman should take his order for a job and analyze it into the separate operations required in his department. As soon as possible, he should make a tentative assignment of every operation to a worker or gang, and to a machine.

The despatcher should make out a set of cards for every operation, filling in "Service Card No.," "Dept. No.," "Order No.," and "Operation No.," as matters of routine. If the job is to be put into work for the first time, the despatcher should strike out "Cont." (Continued). If work has been started on the job, but has been interrupted, he should strike out "Start" on the card which orders work to be continued. This is for the information of the Planning Department. He should then file the set of cards, fastened together by a binding clip, in a file of unassigned work ahead; and as soon as the foreman has decided to whom to give the work, the despatcher should transfer the set of cards to the reserve pocket of the man to whom the foreman has assigned the work.

As soon as possible after a workman has taken his card from the stand-by pocket, thus signifying that the job is in work, the despatcher should obtain from the foreman his assignment for the next job, and should place the workman's card for it in the stand-by pocket. He should then fill in "Employee" and "Operator No." According to the circumstances, he may either fill in "Machine No." then or wait until the workman draws the card from the stand-by pocket.

The despatch board thus handled becomes a picture of conditions in the department. As such the foreman should take a keen interest in it and should often inspect it.

When the foreman is assigning the operations for any order, the cards in the reserve pockets show how much work is ahead of every man, gang, and machine; and the foreman will naturally assign the new jobs to those that have the least ahead of them.

Or, if two men can do the same operation and their reserve pockets show that one has much more work ahead than the other, the foreman can transfer some work from the overloaded to the underloaded worker.

The foreman ought to arrange the cards for as many as possible of the jobs ahead in the reserve pockets in the order in which they are wanted. If two or more men do the same operation, and the reserve cards immediately ahead of one show jobs that are not wanted soon, the reserve pockets of the others should be examined to see whether any jobs that are wanted soon are in them with several other jobs ahead of them. If so, they should be transferred to the reserve pocket of the first worker, and placed ahead of the jobs in it that can wait.

If cards are arranged in the reserve pockets in the

order in which the jobs are wanted, when a man takes his card from the stand-by pocket the despatcher will at once transfer the workman's card for the next job from the reserve pocket to the stand-by pocket.

When the workman's card is transferred from the reserve to the stand-by pocket, if there are no cards left ahead in the reserve pocket, the despatcher should at once notify the foreman to that effect in order that he may look out for work for the man who is in danger of running out.

The cards ahead in the reserve pockets also show for what jobs soon to go into work set-ups have to be made, what tools have to be got in order for them, what materials have to be moved, and to what machines; and in general they give warning of all preparations that have to be made in order to keep the department running smoothly.

It is evident that the despatch board, if used in this way, enables a foreman to watch his department much more closely than he could without it; and that it can therefore effect valuable results, even if conditions are very far from being adapted to the work, and even if the foreman's guess is the best information available as to how long it will take to do any job.

101. The above methods of starting crude planning and despatching should not be considered as an iron-clad procedure, but should be varied as necessary to get the best results.

For example, the purpose of the planning meeting is to determine and enforce departmental and final delivery dates. If this can be better done by some other means, they should be used in preference. The X. Y. Z. Company had established a central planning office which determined these dates and notified the fore-

man, with the job orders, of the dates when they were expected to deliver the work from their departments. The success of this effort was the more remarkable because, up to the time when further improvement of planning was undertaken, the clerks were determining delivery dates solely from the need for the article, without considering the capacity of the departments. Even this had accomplished enough, so that the next step necessary was the introduction of departmental despatching. As soon as that was going, the planning clerks were taught to estimate in advance the capacity of the departments, and to set delivery dates from an estimate of time required in the shop, as well as from an estimate of the date when the product would be wanted.

If a foreman has a very large department, or one in which the technique of the work requires a great deal of his attention, it may be necessary to give him a skilled departmental planner who can relieve him altogether of the details of departmental planning and despatching.

On the other hand, a foreman may be able to handle a small department without any assistance. If the department is very small, or the foreman has a very good memory, he may be able to plan and despatch so well in his head that any formal system would be mere red tape, except in so far as it is necessary in order to provide the office with necessary records.

A similar case occurs where the department carries on a continuous process on only a small variety of articles, in which case planning may be done once for all, and a definite routine established by which the work flows automatically in a continuous stream.

In some cases it may be advisable, instead of hav-

ing a central despatch board, to have pockets for the cards located at or near the men's work places, especially if such receptacles already exist and the foreman has been accustomed to place orders for the men in them. In the latter case, the use of the separate pockets at the work places involves less of a change from previous methods and, therefore, the men more readily adopt it. This method has the disadvantages, however, of taking more of the despatcher's time, thereby reducing the number of men that he can serve, and of making it more difficult for the foreman to get a bird's-eye view of the condition of his department, unless a duplicate board is maintained for that purpose, in which case the chances of error are increased and further demands are made on the time of the despatcher to maintain the duplicate despatching.

The despatch board comes as near as anything can to being a standard device; but under special circumstances I have done departmental planning and despatching by means of tickler files. Always the important thing is to apply the principle of planning and despatching. Devices and methods are secondary.

If the work has been very poorly planned before, so that the workers change their jobs very often, it may be necessary for the foreman first to learn to use the board to plan his work, meanwhile continuing to give his orders by previous methods, and not to have the workers begin to use the board until the foreman has learned to plan his work so well that they will have to change their cards with only reasonable frequency.

Under special circumstances it may be necessary, instead of taking a whole department onto the despatch board at once, to take it on gradually—a gang, or a

few workmen, or even only one workman at a time. In such a case, the extent to which betterment should go with each lot before the next is taken on is entirely a matter of expediency and special judgment.

Sometimes it may be necessary to take the departmental planning and despatching first, at least for some departments, before starting central planning.

102. When a man takes his card from the stand-by pocket, the despatcher should fill in the date and the hour, as "Time Started," in hours and tenths of hours of working time from the beginning of work for the day or the shift. A clock with its face reading in hours and tenths of hours from beginning of work is easily and cheaply provided to facilitate this and to decrease the chances of error. This clock also has been described so many times as not to need further explanation here.

As soon as the standard time has been determined for the job, and efficiency reward has been introduced, the despatcher should fill in "Standard" on the card before it goes to the worker. This enables the latter to see what pace he has to attain in order to earn the reward. It also enables him to see that his making a good efficiency does not lead to cutting down the standard time. See also Article 311.

When a worker returns his card, the despatcher should fill in "Time Finished," subtract "Time Started," and put down the difference as "Time Elapsed."

If the job is not finished, the despatcher should strike out "Fin.," thus notifying the Planning Department that work remains to be done on it.

At the close of every working day or shift, the despatcher should make out continuation cards for the

jobs which are not finished, and should fill the stand-by pockets of the despatch board in readiness for the next day or shift.

In order that the Planning Department may know where it stands, the despatcher, as promptly as possible after the close of the work of every day or shift, should turn in to the Central Planning Department all his cards that were in work on the previous day or shift. Before doing so he should reassemble every worker's card with the other cards of the set, and should clip the three or more cards together again with the inserted carbon papers.

"Sched. No." will probably not be filled in when the cards are first used, because there will usually not yet be any schedules. After schedules have been produced, this blank should be filled in by the Planning Department which should, by that time, have taken charge of making out the entries, "Dept. No.," "Sched. No.," "Order No.," and "Operation No.," on all service cards and transmitting them to the shop department.

Special information under "Details" should, of course, be filled in as circumstances may require.

Reference to Table 1 (page 96) shows that ultimately, as the despatcher makes his last entries on every set of cards, they contain all the information needed by the Paymaster, the Cost Accountant, and the Planning Department, except E, W, and B. These last are permanent information, and should be kept on file by the Planning Department.

103. The Planning Department should fill out E, W, and B. H, the man-hours on the job, is the sum of "Time Elapsed" from the cards of all the workers employed on it. The Planning Department should promptly complete the service cards and then forward

the Paymaster's and the Cost Accountant's copies to them. After those officers have used their copies for making out the pay and bonus rolls, and for costing, respectively, they should place them on file. The Paymaster's copy should be filed by workers. In this way there is built up in the pay office a complete record of every one. The usefulness of this was stated in Article 43. The Cost Accountant's copy should be filed, according to whatever designation will be most valuable in the system of cost-keeping employed, as a permanent detail record of costs.

It is common to file the Cost Accountant's copy by order number, but there are many cases in which some other classification is more valuable. As Coburn says:

> In continuous process plants, like cotton mills, process costs are more valuable than total costs by order numbers; in fact, the latter are of little or no value in watching cost of production. The job of the spinning room is to spin enough good yarn at minimum cost, that of the weave room to weave it cheaply. So that total costs are really of little use in the mill, once the patterns and construction for the season have been determined. In a brake-shoe foundry, the superintendent wants his melting and molding costs; the costs of the orders take care of themselves if the process costs are watched.

The same copy of the service card that has been used by the worker in the shop should be retained by the planning department. This copy is usually the least legible of the three, and should therefore go to the department which, from familiarity with its contents, can read it most easily. It informs the planning department of progress in the achievement of its plans, and enables it to make such revisions of them as the facts require.

After this has been done this copy of the card is of no further interest to the planning department, but it is a good plan to keep it in some permanent file from which needed information can be readily obtained. For example, in the distribution of burden and the determination of hourly rates of equipment, and in revising plant lay-outs to get the most efficient routing, information as to the exact amount of use of every piece of equipment is needed. This card may therefore be filed by machine numbers, unless some better use for it is apparent.

104. In spite of all that can be done toward the Adaptation of Conditions, interruptions and delays will sometimes occur. The standard times set for work should include a reasonable allowance for such minor interruptions of very short duration as can not be avoided. Beyond that it is seldom possible to pay any attention to them.

Occasionally, a serious delay will occur from causes which can not be foreseen; for example, in one plant in which I was working, a sudden cloudburst flooded the basement, making it temporarily uninhabitable.

When any serious interruption occurs, the workers who are delayed by it should receive a special card. It is convenient to make this card of similar form to the service card, but of different color to distinguish it, and with the title, "Exception Card" or "Allowance Card," instead of "Service Card."

It should clearly state the nature of the interruption and its cause, if known. The exception card should preferably state the time of beginning and end of the interruption and the time elapsed, though where an excessive amount of clerical labor would be required to record these times, it may simply state the time

elapsed. This is discussed further in Articles 152 and 299.

The three copies of the exception card should follow the same routing as the corresponding copies of the service card. The paymaster's copy should be filed by workers, in order that that file may contain a complete record of every worker's time. The same principle applies to the planning department's file by machine numbers. In the Cost Department the expenses due to such delays should be figured separately as an item of burden not chargeable to individual orders, articles, parts, or operations. This department should therefore file its exception cards by themselves. This file has a valuable use which is discussed in Article 152.

However, in some cases it is not practicable to have the direct workers change their service cards at the beginning and end of the interruption. For example, suppose that the power goes off for six minutes; the loss of this time might seriously lower a worker's efficiency, but it would only lower all efficiencies still more to have every worker in the shop change his card at the beginning and end of the interruption. Instead the despatcher should make out, for every worker on standard time and bonus, an exception card which should give the duration of the interruption, if possible its cause (in this case, "Power Off") and preferably the time when it began and when it ended.

In all calculations of actual time from the service cards, the exception cards for the date should also be seen. If any cases are found where the service cards have not been changed before and after the interruption, the time covered by the exception cards should be subtracted from the actual time shown by the ser-

vice cards for such cases, thus resulting in a correct net charge for standard time in every case.

105. The service card or equivalent record, made at the time and place of performance of the actual work, has the very great importance of being the foundation of almost all the other records of the business. It is not uncommon to find an elaborate office system based on shop records that are questionable, to say the least. Evidently, attention must be paid first to getting the fundamental records right.

106. Important members of the class of fundamental records are those of temperature, pressure, and other physical quantities, whose regulation may be important to any manufacturing process. The use of automatic recording instruments in such cases enables the workers to act with knowledge of what they are about, instead of by guess, and is valuable higher up for the location of responsibility and the determination of causes of failures.

107. In order that planning and despatching may advance beyond the stage above indicated, it is necessary that betterment should be done in other directions and by the application of other principles.

It is evident that in order to obtain a coincidence of events as to time, it must be known how much time will be required to produce the events. Time studies are the ordinary means to obtain this knowledge; but it must be remembered that the point is to obtain the knowledge, and if some other means will do that better than a time study, the other means is the one to be used.

108. Also the events themselves must be analyzed into their elements, which in this case are the shop operations. The elements of time and events must

then be synthesized into the Schedule, of which an example is shown in Table 3. Obviously the exact form of the schedule in any given case depends upon the work in hand.

The third column of Table 3, "Remarks," is for such miscellaneous information useful to the planner as can conveniently be embodied in the schedule.

Everything that the planner can know about the operations, the product, the materials, the tools, the men, and the shop is useful to him. Very much of this information, much more than can be embodied in the schedule, is worth recording in permanent and convenient form. The forms in which, and the origins from which, this information reaches the planner are so various that it is hopeless to try to standardize its form. It is a good plan, therefore, to file the schedules in large envelopes; and as drawings and other information valuable to the planning office are acquired, to file them in the envelope containing the schedule of the part or article to which they chiefly refer. If any such piece of information refers to several parts or articles it may be most efficient, according to circumstances, either to have copies of it made to file with all their schedules, or else to file it with the schedule to which it most applies, and to file cross references with the other schedules affected. This collection of schedules and of information pertaining to them is called the "Analysis File."

The time studies by which were determined the standard times shown at the right of the schedule ought to be kept on file, but any schedule of the form shown in Table 3 would be swamped by filing with it all the time studies involved. It is usually better to keep the time studies in a separate file, so arranged and

classified that the time study relating to any operation on any part can be readily found when wanted.

109. At the time the schedule shown in Table 3 was made out, the work of symbolizing had not advanced very far. The schedule is shown in this form, because it ought to be got into use as an aid to planning without waiting for the development of a complete symbol system. Of course, operations, parts, partial and full assemblies, and machines ought to be denoted by definite symbols as soon as they can be worked out without taking time from other things of more importance. A sufficient reason for this is that the names which grow up naturally for operations and parts are not uniform even in different parts of the same plant. Consequently, orders given in terms of those names have not such clearly defined meaning as is to be desired.

110. Under "Slides," operation "Taking out cauls," the standard times are marked "doubtful." This means that the times given may be used in planning, but must not be used as a basis for the payment of efficiency reward until they have been confirmed. Such jobs will be paid straight time rates only, until standard time has been reliably determined.

Under "Slide Veneers," operation "Cutting Off," no standard time is given, as it is represented as not yet determined. If a schedule is otherwise ready to go into use in planning, a few gaps in the standard time column should not be allowed to delay its use. Such gaps may be filled in, when occasion arises, by the foreman's guess at the time required, if no better information is available, rather than to allow a long delay in getting the benefit of the parts of the schedule already determined.

111. In planning from schedules like that of Table 3, allowance must be made for the actual efficiency and for the time that the material will lie idle between operations. The time studies necessary to determine the standard times ought also to give average efficiency as a by-product. Dividing the standard time by this will give the time which must be estimated as actually to be used. Average idle time between operations can be determined by a few time studies for that special purpose. It should be one of the aims of planning to reduce the idle time as much as possible.

On this point Coburn says:

> In a certain cotton mill, the value of work in progress as disclosed by recent inventory was $160,000, approximately. The inventory was made very carefully, let us say, so that it was fairly exact and showed the department totals. Now in this mill that figure could be reduced about fifty per cent and still keep a safe margin ahead of each process; it would take quite a long time and much close application and hard work, but, if this effort will release $75,000 in real money, it is worth while. . . . The ideal state of work in progress account would be attained if there were no other material in the plant than that which is actually being worked on. Generally speaking, this ideal is not practicable. But the nearer it is approached the better; and the practicable limit is attainable only by keeping the work constantly moving through the plant. . . . If the progress of work be scheduled in advance, and if the actual progress be regularly reported, then statistics are obtainable from the schedules which will show where the work is being held up—obviously the point of attack.

Of course, as betterment proceeds, the allowances both for actual efficiency and for idle time will have to be adjusted to agree with continually improving performance.

Chapter VIII

RECORDS—PLANNING AND DESPATCHING

Further Development

112.

OBVIOUSLY, when schedules enough have been determined to cover all, or nearly all, of the work of a department, planning its work is no longer a matter requiring the special knowledge contained only in the memories of superintendents and foremen, and planning its delivery dates can be turned over to the staff Planning Department. (See Figure 1, Article 66.) It is desirable that this should be done as soon as possible, in order to relieve the line of the burden of the planning meeting.

The central planning department may either send to the shop department a separate order for every job which is to pass through it, such order stating the date and the hour, if possible, on which materials, tools, etc., will be available in the shop department for the performance of the work, and the latest date and the hour, if possible, on which the shop department is expected to deliver the product; or it may make out for a shop department for every day, and as far in advance as possible, a statement of the work required to be done in that department on that day.

Of the two methods, the first puts the greater amount of work on the departmental planner and the less on the central planner, and leaves the former the greater discretion; and the second puts more work on the central planner and correspondingly relieves the departmental planner, but ties the latter down to a definite daily program. The first method is therefore the more elastic and the better suited for use when planning is first inaugurated, and when, through unadapted conditions and lack of standard times, it is impossible to use much foresight, so that a great deal has to be left to the man who is directly in contact with the work. The second method gives the central planning department the closer control, and is the better suited for use after planning has been well developed.

In putting orders into the shop care should be taken to load every department approximately to its capacity. Neglect of this results in failure to keep promises of delivery. *If work is nominally planned, it also brings the whole planning scheme into contempt to require impossibilities of the shop departments.*

At first, departmental capacities have to be estimated from general knowledge. As conditions become adapted and schedules are determined, these capacities can be more and more closely approximated, but always remain somewhat elastic quantities. This very elasticity indicates the possibility of recourse to the good engineering principle, "When in doubt, make your error on the safe side." The safe side in this case is to put the order into the shop, if it is merely doubtful whether it can be filled—that is, unless it is certain that it cannot be. The elasticity of capacity of the shop departments enables them to take up a considerable amount of apparent overloading, and the

workers will always produce more if they see plenty of work ahead of them. On the other hand, driving will not force, and rewards will not induce workers to take a rapid pace when there is apparent danger of their soon running out of work.

In order that a planning department may hold a foreman responsible for delivery on a certain date, theoretically it should see that materials, tools, and everything else necessary for the performance of the work will be available in the shop on the required starting date; but in practice, if we should wait until we got everything one hundred per cent correct before starting an improvement, we should never start any. In this particular matter the foreman, in all probability, has been accustomed to look out for himself in the matter of his tools, materials, etc., and it may be best to allow him to continue to do so until the planning department can get on its feet in planning work out of his department; but evidently the planning department should plan his materials, etc., for him as soon as it can.

If the line is not particularly burdened by the planning meetings, it may be well to allow such meetings to continue until the planning department can see that a department has its materials, tools, etc., when they are needed, before undertaking any planning of operations. The exact order in which steps are taken must vary with the necessities of the case in hand. If materials have been selected as the first thing in the whole plant on which to work, it would be natural to plan the deliveries of materials to departments before beginning to plan the work of any department.

113. In order that the planning department may plan as to materials, it must know the amounts on hand and

the amount required for the manufacture of any order. This involves the creation of two sets of records, Bills of Material, which should be filed in the Analysis File with the schedules to which they apply, and Perpetual Inventories, or stock ledgers, of materials. This does not mean that these records must be complete for the whole plant before the planning department assumes any control of materials. When efficiency work is being concentrated on any department, these records may usually be got out for it, and the planning department may take over the work with reference to it without waiting for other departments.

The Bill of Material, as an adjunct of engineering drawings, has so long been familiar that probably no further discussion of it is necessary, but it may be well to explain the perpetual inventories.

The information needed in the perpetual inventory is as follows:

Articles into whose manufacture the material enters, as a cross reference to the analysis file for general information not conveniently carried on the inventory itself;

In the case of any worked material, cross references to other worked materials, if any, which can advantageously be manufactured in combination with it (see Article 157);

The location of the material in stores;

The nature of the material, as wood, stone, iron, liquid, etc.;

The dimensions of one unit of the material (where dimensions are not simple, this should be given by reference to a drawing or specification) and perhaps also unit weight;

Amount and date and number of order of all material ordered;

Amount and date of reception, and order number, of all material received;

Amount of all material reserved, and dates on and orders for which it is reserved;

Amount of all material delivered and date on and order to which it is delivered; and

Amount of material available in stores on any given date.

The usefulness of the perpetual inventory is very much increased if it also states maximum and minimum limits of the stock.

In order to be adapted to changes without any resulting confusion, the inventory must be in loose leaf or in card index form. It is next necessary to design a form to contain the desired information, which shall also be suitable to the filing arrangements available.

Fundamentally, the minimum limit of stock is the product of the average rate of use of the material and of the average time required to obtain a new supply, both determined by previous experience. This product may be called the theoretical minimum. The result must be tested and corrected by general knowledge. When the data are insufficient, or for other reasons the result is in doubt, it is well to add to the result a safety reserve, just as the engineer adds a constant to rational formulas for the dimensions of parts subject to corrosion. The final result may be called the actual minimum, or low limit.

If the average rate of use of the material and the time required to obtain a new supply were constant and definitely known, there would be no need of a safety reserve. If then a supply equal to the minimum

limit were ordered just as that limit was reached, it would be received just as the supply was exhausted, would just bring the supply on hand up to the minimum, and it would again be time to order a new supply. This condition would be met very simply by making the maximum limit equal to the theoretical minimum plus the actual minimum, and by ordering the difference between maximum and minimum whenever the actual minimum or low limit was reached.

In the case of worked materials and finished stock, the amount to order ought to be determined so as to secure manufacturing efficiency; and the maximum limit would then be the minimum limit plus the amount to order. In the case of these materials, the maximum ought to be calculated both ways, and the larger result should be used. After the maximum limit has been calculated as above, it ought to be tested and corrected by general knowledge.

We are always looking for automatic devices as substitutes for human watchfulness. The methods of efficiency can not be safely used in that way. If they are regarded as aids to watchfulness and intelligence, they are very valuable; but, if they are allowed to take the place of brains, they are dangerous. In this connection, the stock clerk ought to be told that he must never allow any manufacturing process to be delayed by exhaustion of the supply of materials; to do that he must be alert and intelligent; the limits on the stock are intended to help him to accomplish the desired result, but never to excuse him for failure.

As a practical result, the maximum limit prevents over-stocking, and the minimum limit adds to the safety of manufacturing processes against delays due to lack of supplies.

In the absence of a maximum limit, everyone connected with manufacture tends to play safe, because delay due to lack of materials is pretty sure to call down wrath on anyone who can be blamed for it, while, without a maximum limit, it is always debatable whether there is an overstock or not.

In spite of the tendency to play safe, some article of stores will be reduced occasionally without anyone's noticing it, and the result will be exhaustion and delay of manufacture. If there is a minimum limit, it is definitely the duty of the clerk to compare his amount available with the minimum limit every time he credits stores with an amount delivered. The minimum limit thus acts as danger signal. The stock clerk is not likely to run past it without placing an order for more material; and if he does, the responsibility is definitely located.

The maximum limit ought not to prohibit the Purchasing Agent from taking advantage of a low market or from buying in quantities large enough to get a low price, but he ought to use the two limits to guard himself against buying excessively at any time.

When any article reaches the minimum limit the inventory ought to be corrected by a physical count. By so doing the substantial accuracy of the inventory is assured at all times, all articles are inventoried when there is least labor in doing so, and the delay to manufacture and the expense of an annual inventory are greatly reduced.

The proper place for the perpetual inventory is in the Central Planning Office (See Figure 1, Article 66) under the Chief Planner. The Purchasing Agent and the Store-keepers occasionally need information from the inventory which they can get when they want it.

This condition indicates the convenience of a general office in which the Chief Planner, the Purchasing Agent, and the Chief Store-keeper can all be located.

114. In order that materials may be entirely under control, and also in order that responsibility for them may be properly located, all materials must be drawn from the Stores department on written requisitions.

These requisitions are conveniently made up in the form of Material Service Cards, which are very similar to the Labor Service Card shown in Figure 2, Article 96, and are designed on the same principles. Supposing that a bonus is paid for efficiency in the use of materials; the fundamental data for the design of a material service card, in an illustrative case, are given in Table 4.

TABLE 4.

DATA WANTED FROM MATERIAL SERVICE CARDS

By Paymaster	By Cost Accountant	By Planner
Workman's Number		Workman's Number
	Article	Article
	Kind of material	Kind of material
	Quality of material	Quality of material
Amount of material used	Amount of material used	Amount of material used
Standard amount of material for the job	Standard amount of material for the job	Standard amount of material for the job
Unit value of the material	Unit value of the material	
	The order number	The order number
		Machine number, or other designation of the place where material is to be put in work
	Amount of main product	Amount of main product
Value of by-product	Amount and value of by-product	Amount of by-product

The paymaster's data enable him to calculate the actual and standard costs of the materials for the job

and the value of by-product, if any, with which the workman is to be credited; and these form the basis of the bonus on materials, as is explained in Article 302.

When planning is first started, and the central planning department's control is still necessarily somewhat loose, it will probably be best to furnish the departmental despatchers with blank requisitions for material. Inspection of the despatch board from time to time gives warning when any job is approaching the need for material, and the despatcher, under the direction of the foreman, can then make out the necessary requisitions and forward them to the store-room. The designation of the work place on the requisition may serve as a move order to transport the material at once to the required place, or it may be desirable to make out a separate move order which directs when and where to deliver the material.

It is usually best to transfer the making out of the requisitions for materials to the central planning office as soon as possible.

That office will then, by its requisitions, or by requisitions combined with move orders, and by orders to tool rooms to have necessary tools in readiness, and perhaps also to set up machines, make sure that everything will be ready for a job at the time and place desired, and will then base its further planning on that assurance.

As soon as the perpetual inventory and the bills of materials are ready and the requisitions for materials have been put into use, the central planning office when it receives a manufacturing order will first examine the inventory to see whether it has the necessary materials. Of course, no job can be ordered into work un-

less the necessary materials are on hand. If they are not, it will be up to the planning office to see that they are provided as quickly as possible.

The routing of the different copies of the material requisitions will vary somewhat according to circumstances, but each must *soon* reach the officer for whose information it is intended. The planner's copy then furnishes the data for the credits which the stock clerk enters on his perpetual inventory as amount of material delivered.

The Paymaster's copy should be filed against the worker to whom the material was issued. This card adds to this file the record of the worker's efficiency in the use of materials. The Cost Accountant's copy should be filed against whatever designation is most suitable to the cost system used. (See Article 103.) The Planner's copy should be filed against material.

115. The perpetual inventory and the material requisitions may displace former methods which imperfectly accomplished the same purpose. *In any such case, it is important that the old methods should be continued until the new have been thoroughly tested and the organization has learned to handle them.* When this stage has been reached the old methods can be discontinued.

116. In order that planning may be done accurately, the times necessary for operations, that is, the Standard Times, must be known. (The determination of these is discussed in Chapter X, Standards, beginning with Article 186.) In order that standard times may be realized there must be Adaptation of Conditions and Work to Each Other, work must be done by Correct Methods, and the workers must have an Efficiency Reward for approximating the standard times. Progress

must be made in the application of the principles here mentioned before Planning and Despatching can advance further.

117. Meanwhile, there will be considerable error in the plans laid down by the central planning office, and this error should be continually reduced, although it can never be absolutely eliminated. One of the main reasons for the use of the methods of departmental planning and despatching above described is that this error may be corrected by persons having that intimate knowledge of details which results only from close contact with the work. It is also necessary that the central planning office should be continuously and promptly informed of the actual facts, and should revise its main outline plans accordingly.

It is for this reason that all outstanding service cards should be closed out at the close of every day or shift, and that all service cards which record events during that day or shift should be forwarded to the central planning office as soon as possible thereafter.

118. The central planning office must keep records of its plans. At first, and possibly as long as the planning office is merely putting into the shop orders on which it requires delivery on a certain date, the tickler file outlined in Article 91 may answer the purpose.

Referring to that example of the tickler file; at any convenient time before September 13, the planning office might put an order into Department 1 for the required number of Part A to be delivered to Department 3 on September 27. From September 14 until the parts were completed and delivered, the planning office would consult the service cards coming in daily from Department 1 to see what progress was being made on the order for Part A. As soon as there ap-

peared to be any danger of failing to make delivery on the twenty-seventh, the planning office should take the matter up with the foreman of Department 1, and should revise its plans so as to obtain the best result still possible. Suppose, for example, that the service cards for the thirteenth failed to show Part A as started on that date.

Consultation with the foreman might show that—

The foreman expected to start later and still make the required delivery, in which case no action might be necessary; or

There had been a failure to start according to plans, in which case, if the foreman were to blame, the planning department ought to report the matter to his line superior and one or other of the following actions would be necessary:

Overtime on Part A:

Displacement of some other order to make room for Part A, in which case the planning department would have to revise its plans and the tickler file for the orders displaced; or

Acceptance of delayed delivery of Part A, in which case the planning department would have to revise all its later plans on the tickler file for this order so as to harmonize them with the delay, and to revise its orders to the shop accordingly.

As the planning department develops closer control, it will be necessary for it to keep records of its plans in more detail. The items of information that it will need for this purpose are—

Department in which each operation is to be performed:
Order number;
Article ordered;
Quantity of finished work ordered;

Final delivery date of assembled articles;

Date and approximate hour, if possible, on which to begin assembly;

Delivery dates of all parts constituting the assembly;

Date and approximate hour, if possible, on which to begin manufacture of every part;

Machines and other equipment which can be used for every operation;

Workmen who can be used for every operation;

Name or symbol of every operation;

Amount of other work which must be put through every operation;

Order of time in which all work awaiting any operation must be sent to it;

Amount and estimated time duration of all work awaiting every operation.

The above information must, of course, be systematically recorded in standard forms designed to suit the case. Knoeppel gives a very good one ("Daily Planning Sheet") derived from a machine shop.[1]

In proportion as the planning department's information on the above points is complete and reliable it can assume more and more detail control of shop operations. In so far as it lacks knowledge of any of them, it must leave corresponding discretion in the planning to the departmental foreman and despatcher.

119. When the planning department reaches the stage of laying out in advance a definite day's work for a department, it will probably be necessary for it to plan the progress of every order from machine to machine and from operation to operation in order to be sure that its plan is feasible and that it fits the departmental capacity.

When this stage is reached the foreman has very little concern with the planning, as all that is necessary, as long as things go right, is for the despatcher

[1] "Installing Efficiency Methods," by C. E. Knoeppel; The Engineering Magazine Co.

to manipulate the despatch boards and service cards according to the plans of the central department. This is a great relief to the foreman and enables him to give much more attention to the technique of his work, to the instruction of his workers, and in general to the efficiency of his department.

Referring to Figure 2, Article 96, the central planning department should now fill a serial number in the blank "Service Card No. ...." before forwarding the cards to the department. The service cards then constitute sufficient orders to the shop department for work to be done, and the serial numbers of the cards indicate to the despatcher the order in which the jobs are to be put into work.

It is also necessary now for the planning department to keep closer track of progress in filling its orders than it could do at first by the use of the tickler file. It should keep records showing how far advanced every order should be on every day, and the actual advance should be noted daily from the service cards and compared with what had been planned.

Those orders that are farthest behind are of course the ones that require the most forcing in the shop; and the planning department must revise its plans so as to accomplish this.

120. However detailed the control of the planning department may become, the shop executives, and even the workers, should not be shut off from suggesting changes and improvements.

121. A difficulty is apt to arise in planning in connection with articles which are damaged in manufacture. Where goods are ordered to stock, or where, for any other reason, it is possible to leave the amount of the order somewhat indeterminate, it can simply

go through, less the damaged articles. In that case, those articles may be worth repairing and putting into salable shape, even if only as seconds. The regular work in the shop gets along most efficiently if all repairs to these damaged parts and all other special work is put off by itself where it will be completely out of the way of the regular work. For example: in shoe factories it is customary to run a small "Cripple Department" which is in itself a little shoe factory, and to send to this department all damaged shoes as soon as they are discovered. On account of the unadapted conditions under which it works, a department of this kind may be very inefficient; but, because of its small size, its efficiency is not a great financial consideration, while if the special work which it does is put into the main factory, confusion and inefficiency is created on a large scale wherever it goes.

Probably it would not pay to provide expensive equipment for a repair or other special department on account of the small scale and variety of its operations, but it is better to do its work by hand than to lower the efficiency of the whole factory by putting its work into the regular manufacturing departments. Where a special department is not practicable, a few special workers in the manufacturing departments, out of the way of the regular processes, are the next best solution.

Where an order has to bring through a certain number of pieces and it is possible to put any excess pieces into stock, it is best to start the order with sufficient excess to assure its bringing enough through, and to put the excess, if any, into stock. Where excess pieces can not be put into stock it is usually necessary to start the order with the exact number, and if any have to be

rejected in process it is usually best to put the order aside until the special department has made good the damage, and then to start it on again. If the order is sufficiently large to be efficiently manufactured in part lots, these delays can be limited to the last lot which can be made to carry an excess equal to the losses of all the previous lots.

Whenever work is rejected, the inspector should at once record the kind and amount, the nature of the damage and, if possible, the cause of it. This record may sometimes be made a part of the service card that ordered the operation at which the work was rejected. If this is not feasible, the rejection should be recorded on a separate form of which a copy should accompany the service cards to the planning office.

The records of rejections should be kept on file, and at regular intervals, once a month or so, a clerk should go over them and summarize the nature and causes of damage and the amount of loss attributed to each during the last previous period, and should report the summary to the Chief of Staff. (See Diagram of Organization, Figure 1.) The latter, if any particular nature or cause of damage has considerable loss attributed to it, should set about its correction through the line and staff organization concerned.

122. An assembly department usually presents difficulties in planning. Here parts from several different departments have to be brought together to unite in one assembly; and the greater the number of parts, the greater is the difficulty in carrying out the plans so perfectly as to bring all the parts together at the same time. For example: in a shoe factory, lasts and uppers come together in the last gallery. The uppers have just come from the fitting department, which is

itself an assembly department where the outer uppers and the linings are assembled out of their parts and are also assembled with each other into the complete upper. The lasts have just returned from the operation of last pulling, up to which they had travelled with a previous lot of uppers from the last gallery. It is exceedingly difficult to bring either uppers or lasts through to the last gallery without considerable error from the times calculated by the planning office. Therefore a store room of uppers and lasts is provided in connection with the last gallery, and uppers and lasts as they come in are put into stores to await the arrival of their mates. The service cards coming in daily will show what uppers and what lasts have reached the last gallery during the preceding day, and the planning department should start its plans all over from there.

However, the delays to both uppers and lasts, and consequently the stock of them tied up in the last gallery, are reduced if the planning department has definitely planned for them to come together there at a certain time, instead of starting uppers regardless and trusting to their coming together hit-or-miss with the lasts. This is especially important in the case of the lasts which are expensive and quickly become out of date on account of changing styles, so that the factory needs to get along with as few of them as possible.

123. This is the example of the sub-principle of the reservoir which is applicable to points where planning is difficult. The principle is to carry planning only up to the reservoir, store the product in it, and start new plans for operations from the reservoir according to conditions in it.

The disadvantage of the reservoir is that the value

of the goods in it is idle capital. One object of planning should be, therefore, to reduce the size of the reservoir; and this it can do by reducing its own errors, since the necessary size of the reservoir is proportionate to the amount of error in the plans.

124. Referring to the illustrative example given in Article 91 of a tickler-file program, it will be noticed that the final delivery date of the finished article is the starting point of the whole calculation, and that from this the date for every preceding event is worked out. This is typical, as planning works backward; first deciding what is to be the ultimate achievement and when it is to be accomplished, and working out from that the time for the tributary events.

125. This is directly opposite to the practice of the unplanned shop wherein the material drifts along the stream of manufacture, and the work to be done at any operation at any time is often left to the individual workman who, of course, does what is most convenient for him at the time without regard for its co-ordination with other events.

Local efficiency, of course, should have its share of consideration. For example, if a long set-up has been made on a machine, local efficiency would require that it be kept and that orders requiring it should pass through the machine without interruption for as long a time as possible, but this might unduly delay some other order and cause great inefficiency elsewhere. The requirements are conflicting, and that compromise which gives the best all-around result should be made. Evidently the individual workman cannot judge correctly. Even the foreman, unless guided by central planning, cannot, because he has only a departmental view of the matter.

126. Every manager recognizes, at least in theory, the value of co-operation and co-ordination, and an effort to secure them will convince anyone of the complexity of the problem. No such problem can be solved by leaving it to chance, but this one can be solved by thorough planning, and by despatching according to plans.

127. The ultimate ideal of planning and despatching is to lay out in advance for every order a definite timed program of progress from operation to operation through the plant, and to despatch it according to that plan—an ideal which probably can never be fully attained, but which can be continuously more and more closely approximated.

128. To whatever degree of perfection planning may be developed, the planning department must never lose its ideal of continuously improving its plans in the light of more perfect knowledge as the event planned is seen more perfectly on closer approach, or as changes and unforeseen conditions produce unexpected situations.

Some people object to planning, apparently with the idea that a plan once laid is like a pair of steel rails which must be followed without deviation, or disaster will ensue. Any efficient plan is more like a broad waterway over which the navigator does indeed lay a course, but on which he is free at any moment to shift his helm, to stop, or to go astern.

129. As soon as labor and material service cards are fully in use with standards determined, the foreman of the department has the means of knowing, at any time after his department receives an order for a job, how much direct material and how much direct labor ought to be spent on it, and while the job is still in

progress he can tell whether the standard of material or of labor is likely to be exceeded. If the foreman has his own Efficiency Reward based on the efficiency of his department in these respects, he is apt to be very much interested in what the service cards show as to jobs in progress. If he is not, another foreman would be the best solution. The important point as to the Record is that it is so *immediate* that the foreman can know the facts while there is still a chance to save the money that is going to waste, and that it indicates to him exactly the weak points that require his attention.

Another point at which the foreman may control on the spot the direct cost of operations in his department, is his selection of the quality of both labor and material. It would obviously be a waste of good material to use sound oak as a core to be veneered. It is not quite so obvious, but might be equally wasteful, to use mill culls for the purpose, instead of "sound wormy" chestnut. Also it might be equally inefficient in the use of labor to assign either a skilled mechanic or a laborer to a job that ought to be done by a good machine operator.

If the foreman accomplishes a good efficiency as to quantities of both material and labor used, and judiciously selects the quality of both, he evidently does all that he can to keep down direct costs in his department; and a money statement of those costs would be of no interest to him, nor ought he to be held responsible for their amounts.

When bills of material have been made out and the central planning office has taken over the preparation of requisitions for materials, the quality of materials for any job would evidently have become standard-

ized, and the foreman would not have to look out for that and could concentrate his attention on the matter of quantity.

Planning must have become very refined before the central planning office can assign jobs in advance to individual workers. Long before that stage can be reached, the standard grade of worker should have been determined for at least a very large percentage of the work of a department, and these determinations ought to be expressed to the foreman and, for his guidance, in written standard practice Instructions.

To what extent the foreman can be provided with immediate, adequate, and reliable records of his indirect expenses, and to what extent he can be held responsible for controlling them, does not admit of a general answer. For example, if his department has electric drive throughout, it may be possible to show its power consumption continuously on a recording wattmeter. If it is also practicable to determine, even roughly, a standard of power per unit of product, the foreman can be given an Efficiency Reward based on efficiency of power; and it is then safe to say that machines running idle, shafting running unoiled, and belts running too tight or too slack, will all interest him very keenly.

On the other hand, if there is no means of separating his power consumption from that of other departments, the place to which to apply records, standards, and efficiency reward as to power, will vary with all the local circumstances.

130. Referring to the Organization Diagram, Figure 1, the next line superior to a foreman is a superintendent. Every superintendent is properly responsible for efficient operation of the group of departments that

come under his authority. Fluctuations in volume of work also interest him, as they have an important effect on the welfare of his group, even though the efficiency may be satisfactory. Therefore, at frequent intervals, usually once every pay-roll period, after the close of the period there should be made out for every superintendent, as to every department under his authority, a statement of

Total direct labor for the period,
Standard direct labor for the period, and
Efficiency of direct labor; also of
Total direct materials for the period,
Standard direct materials for the period, and
Efficiency of direct materials.

The situation of the superintendent with reference to indirect expenses is very similar to that of the foreman, but, referring to the example of power in Article 129, though it may not be possible to separate the power used by a foreman from that used elsewhere, it may be perfectly possible to separate from the records of all other power the record of the power used by the group of departments controlled by a superintendent and to set standards for it. The remarks made above as to power consumption and the foreman would then be moved up the line one step to the superintendent.

Throughout the chain of command we ought, as low down as possible, to bring in records of actual quantities, standards and efficiencies.

131. Records which go to executive officers should be designed to draw their attention forcibly to the exact spot where it is wanted. For this purpose graphs are much more effective than statements presented in tabular form.

A common form of graphic record for this purpose is shown in Figure 3. Both actual and standard quantities will vary with the amount of work done. This can not be avoided; but if, as in the fifth, sixth, and seventh periods of the illustration, the efficiency falls with decreasing volumes of business (as it is very apt to do) the situation is doubly alarming. If, beginning with the eighth period, as shown, the efficiency begins to climb steadily, the responsibility of the officials concerned is satisfactorily met, no matter how the owners may worry about small volume of business.

DEPARTMENT NO. 1

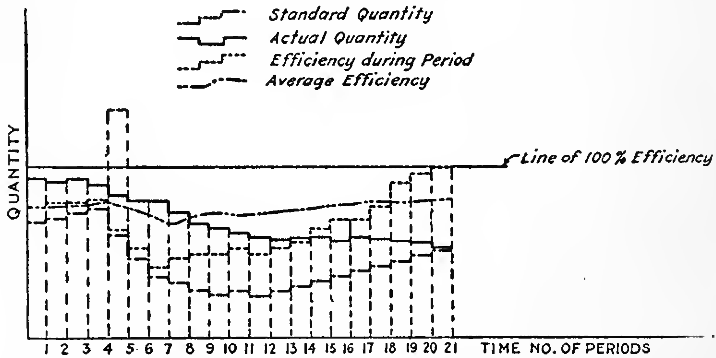


FIG. 3. GRAPHIC RECORD OF DEPARTMENTAL EFFICIENCY

All hands are interested, however, in absolute quantity as well as in efficiency. If the actual expenditure should shoot up, as shown dotted in the fifth period, all concerned want to know why such an abnormal quantity was expended, regardless of the efficiency. It might, for example, if an unusually large amount of either material or labor were expended, mean a serious over-stocking, which ought to be promptly stopped.

Graphs of indirect expense are peculiarly subject to

such irregularities, due to the fact that apparent expenditures often do not synchronize with the actual. For example, a lot of repairs may be made in a few periods, resulting in an enormous charge for maintenance during that time, while the repairs made may suffice for years. In such cases a graph of averages is especially valuable, as it shows correctly the general tendency in spite of temporary wide fluctuations. In order to cover seasonal fluctuations, the averages as expressed in their curve ought usually to be determined for the year that ends with every period of the graph. In starting the graph, if previous figures as to efficiency are not available, the average should cover all the periods for which the periodic average is known, and so on, until the figures for one year are available.

A well designed graph, which presents just the essential facts in a striking manner, is one of the best means of enabling an officer to focus his attention just where it is needed. (See Article 53.) Returning to the case of the superintendent: when his periodic graphs reach him he can quickly run over them, and those that show satisfactory performance, he can have filed as requiring no further attention; but supposing the labor graph of one of the departments to show a falling off in efficiency during the previous period, the superintendent is thereby strongly notified that labor in that department requires his attention.

132. Going a link further up the chain of command, the Factory Manager should have similar periodic reports, but more condensed. Actual totals, standard totals, and efficiencies of direct labor and of direct materials should be reported to him for the factory as a whole. If the showing is satisfactory, he need

not worry about them, knowing that any local inefficiency has been brought to the attention of the superintendent and foreman concerned and that it is not big enough, at any rate, to affect the final showing. While actuals, standards, and efficiencies of indirect expense ought to be reported to officers lower down than the factory manager, if possible, they can certainly be so reported to him and ought to be.

133. When we mount one link higher to the President, or General Manager, we come to an officer whose point of view is different. No matter what labor, materials, and overhead may cost, the vital thing to him is, "*How much does the product cost?*" To him, therefore, should be reported periodically, amount of product, total actual factory cost of product, actual cost of product per unit, standard cost of product per unit (see Article 224), and efficiency of cost of product. Even though efficiency be one hundred per cent, he is still concerned to know whether the actual cost is low enough to meet competition; and if it is not, a revision of the standard may be necessary.

134. The system of reports above indicated affords the means of running down the cause of any excessive costs immediately, and of setting in motion the necessary correction. Supposing that the report to the President shows that some competitor has got below his standard cost for some article, so that a revision of its standard cost is necessary; this is a matter to take up with the chief of staff who, through the staff organization, should investigate and should recommend such measures as are feasible to reduce standard and actual cost.

If, however, the reports to the President show that the *efficiency* of cost of some article of product is low,

this is a matter to take up with the factory manager, for some of the factory efficiencies must be low to produce this result. The reports to the factory manager show at once what these low efficiencies are.

Supposing the report to the factory manager shows a low efficiency of labor, conference with the superintendents and inspection of the reports made to the latter as to labor will show at once in what departments this efficiency is low. The other departments can be dismissed from consideration, attention can be concentrated on the departments making a poor showing, and the factory manager is justified in demanding of the superintendents concerned that the efficiency in them be brought up.

Examination of the service-card file by man numbers in the paymaster's office will show exactly what workers have fallen down, and the superintendent then has the exact location of the trouble and can act accordingly. The foremen concerned, however, ought to know already from their daily examination of service cards in work in their departments just where to give their attention to bring efficiency up and cost down.

135. An employer to whom something of this sort was explained, replied that he should expect the foreman to know that anyhow without any service cards. The only reply to this is that, as a general rule, *the foreman does not know.* In the absence of records, how can he? He has nothing then but general impressions to guide him, and experience has shown them to be utterly unreliable.

136. Copies of the superintendent's records, mentioned in Articles 130 to 133 as going to the line officers of the rank of superintendent and above, should go to the Chief of Staff as well, for while the line officers are

responsible for everything under their orders, efficiency is the special care of the Chief of Staff, and through the staff departments and his position as counselor to the higher line officers he can come powerfully to the aid of the line in improving any low efficiencies.

137. A point which cannot be too strongly emphasized in the above explanation of records is the presence throughout, always and in every record, of the *standard.* Without this the record is valueless, except in so far as the officer using it can supply a standard from his own general knowledge. Without the standard there is no means of knowing whether performance is good, bad, or indifferent; and lacking this knowledge, intelligent action is impossible.

Efficient records must be *immediate* and must report the *standard* as well as the actual.

138. In Article 44 mention is made of the records of employees to be kept by the Employment Supervisor, and of their value. The principal records of this kind are—

Names, addresses and qualifications of applicants for work;

Specifications of the qualifications for every position;

Summarized records of every employee, including attendance, efficiency, and general qualifications in comparison with the specification for his position and also with a view to discovering his greater fitness, if it exists, for some other position.

Summarized records of the rate of change of employees, and reasons for same in every department.

The attendance and efficiency of employees can be abstracted from the service-card file by man numbers. The record of other qualities should be obtained by

having every officer report regularly to the employment supervisor on his own immediate subordinates.

The record of rate of change of employees and of the reasons for change, if used to decrease this rate, is very valuable, as pointed out in Articles 36, 41, and 48.

139. A record not commonly found is a card-index record of equipment, in which should be summarized the characteristics, first cost (including cost of transportation and installation), and history of every piece of equipment. To this should be added an annual estimate of its obsolescence, and of its actual value, not on the market but to its owner. This record is valuable as providing the basis for Anticipative Inspection, which is discussed in Article 162, and as showing the real depreciation. It is evident that serious mistakes in business policy may be occasioned by an error of tens, or perhaps hundreds, of thousands of dollars in figuring the annual charge for depreciation of equipment; and the only way of determining the actual depreciation with any degree of accuracy is by such a record as that above recommended.

In a plant in which the belting works under conditions which are at all severe, its record should be similarly kept, but it is usually most convenient to keep it separately. The object of this record is similar to that of the record of the rest of the equipment.

140. Other records which are commonly lacking are specifications of materials. In the absence of these the result is almost sure to be that the Purchasing Agent will buy for cheapness of first cost only. This causes trouble all through the manufacturing process, inferior finished product, and loss of reputation and business.

141. Commonly, knowledge of setting up machines,

of manufacturing processes, of formulas for mixtures, and so forth, exists only in the heads of individual employees. This makes the business very dependent on such individuals. I have seen a good sized plant which a few foremen could have tied up by refusing to use their knowledge of tools required for processes. Employees who thus have a business in their power are not apt to be at all considerate in the way they use it. The only way to escape from this dangerous situation is to get such knowledge into written records. These records are commonly put in the form of Written Standard Practice Instructions. (See Article 237.)

A large ship yard had depended for its knowledge of its underground wiring, piping, and so forth, entirely upon the memory of the foreman in charge of it, and he was very careful to keep this knowledge to himself. This method was never satisfactory, and when the foreman died it resulted in such confusion that the management had a complete subsurface survey of its plant made and mapped. A by-product was the discovery and recovery of abandoned copper enough to pay the cost of the survey.

142. I refrain from generalizing from my own experience, but personally I have been astonished by the number of concerns that have no drawings of their products. Doing without drawings, I suppose, to avoid the expense of the drafting room, results in parts and assembled articles being designed without sufficient attention to the adaptability of the equipment, or to the co-ordination of designs with each other. This is discussed further in Articles 156 and 158.

143. In the beginning of betterment work, when attention is necessarily confined to the big things, a great many minor improvements can be foreseen which

would distract the force from the matters in hand if they were undertaken at once. These should be recorded for future reference. I have found a file of five-inch by three-inch cards very convenient for this purpose. This file should be consulted at frequent and regular intervals, in order to take up the matters therein suggested as soon as an opportunity occurs.

144. It would be outside the purpose of this work to go into an explanation of the general system of records connected with the management of a business, and it would also probably be only a review of matters already familiar to the reader.

145. The drafting room is commonly a department for the preplanning of materials and the preparation of instructions for their use according to the plans. In some cases the preplanning of materials can be further extended with valuable results.

In shoe factories, for example, a standard piece of fabric from which uppers or linings are to be cut is often planned so as to cut the pieces from it with the least waste; and this pattern sheet, with the pieces marked on it as they are to be cut out, is furnished to the operator of the dinking machine, who is expected to cut pieces of that fabric according to the pattern.

Hides cannot be cut to a standard plan, because every hide is different from every other. The cutting of every hide must therefore be planned by itself. A similar condition exists in cutting steel shapes for structural work in jobbing shops, in cutting up lumber for furniture parts, and in other places in industry.

In such cases a workman commonly cuts every piece with only such preplanning as he can do in his head as he goes along. Common Sense, confirmed by experimental tests, shows that a man can plan such a

piece before cutting with much less waste of material than he can cut it piece by piece without preplanning.

A difficulty exists in recording the plans so that they can be followed in cutting. Where patterns or templates can be laid on the piece, this furnishes a quick and easy way of planning, and the plan can then be very quickly recorded by spraying the piece with suitable pigment from an air brush. This has the further advantage that the pigment is deposited on the scrap only.

The handling of the piece is about doubled by preplanning, marking, and cutting to plans, as compared to cutting without preplanning.

On the other hand, the cutting of preplanned work can often be done by cheaper labor than is necessary to cut work not so planned.

Such preplanning of materials, such as those above mentioned, involves, therefore, increased cost due to the air brush equipment and to additional handling, and offers economies by decreasing the waste of material and in reducing the labor cost of cutting.

It is a matter for independent investigation in every situation as to whether such preplanning will show a net loss or gain in total cost. The making of such investigations is discussed later in Articles 186 to 213, and in Article 221.

Chapter IX

ADAPTATION OF CONDITIONS AND WORK TO EACH OTHER

146.

IN order that correct standards may be determined, the work and the conditions must be adapted to each other, or at least the effect of such adaptation must be foreseen in setting the standards. In order that correct standards may be attained, such adaptation must actually have been effected. For example, time studies may show a low efficiency due to a lack of any of the adaptations of conditions listed in Article 154, or of others; and obviously the inefficiency can be corrected only by removing its cause, that is by adapting the condition.

147. Since there is usually only one best, adaptation generally results in making conditions uniform; hence, the principle of adaptation is often called the "standardization of conditions." For example, a progressive factory manager on taking up work with a certain company found that in the punch-press department identical machines were running at widely different speeds. The question of speeds was studied and the best speed for every type of press was determined. Every press of the same type was then brought to the same speed.

Obviously, the time to do any job on one of these presses was dependent on the speed of the press itself; hence, with all the presses running at different speeds, there would have been needed for every job as many standard times as there were presses. It is evident how much such a condition would have complicated the always complicated task of planning.

For a press running below the proper speed, the time to do a job would evidently be longer than necessary, so that a standard time for the slow machine would not represent good performance. This further exemplifies the fact that conditions must be adapted before correct standards can be attained.

148. Adaptation of conditions does not always lead to uniformity, or standardization. For example, in the same punch-press department a small amount of work was fed hot to the dies. For this work one press of each of the smaller types was fitted with a gas heater. A blind application of standardization would have led to the fitting of the same heater on every press of those types, which would have been a waste of money.

Mention has been made in Article 4 of the fact that one must sometimes adapt the work to the conditions, instead of adapting the conditions to the work.

149. It might seem at first glance as if adaptation must be done thoroughly before any other betterments could be undertaken, but this is not the case. In the chapter on Planning it was explained that crude planning may be installed to the considerable improvement of efficiency in advance of adaptation of conditions. In Article 55 it was pointed out that instruction is the complement of adaptation, effecting by increase of skill in the individual what is not accomplished by adaptation. In fact, every one of the other principles

is capable of some application in advance of adaptation of conditions.

Some adaptations are very expensive and the owners of the business may not be able to finance them until money has been saved in other directions. The routing in many American plants is not good. As "routing" is used by many people in a sense very similar to that of "planning," I define it for the purpose of this discussion, as the route or path followed by the material in moving from operation to operation through the plant. Any extensive remodeling of the routing must be very expensive both in itself and by interfering while it is in progress with the regular work of the plant. The owners of a plant may well feel that they need to be helped in other ways before anything so radical can be undertaken.

In a furniture factory in which the routing was apparently bad, time studies failed to show any considerable loss from this cause. This would not justify abandoning all intention of doing anything with the routing, but it did justify putting it out of consideration as a matter for early attention.

All proposed betterments, and especially those involving any considerable expense, should be subjected before they are undertaken to careful analysis by time studies or otherwise; their probable cost ought to be estimated and assurance ought to be obtained that they will at least repay the expense.

On the other hand, there may be unadapted conditions so bad that very little progress can be made until they are corrected; or there may be others which can be corrected at small expense with large gains in efficiency, and are, therefore, among the most advantageous objects of early attention.

One of the things for investigation in connection with the selection of the point of attack (see Chapter XVIII) is whether there are related to it any such unadapted conditions; and, if so, how much money can be saved by adapting them, how much the adaptation will cost, and how long it will take.

150. There are several means of obtaining this information. The most important of these is the time study, or, in the case of materials, a similar analytical study of them. In making either a time study or an analytical study of the use of any material, care should be taken to note collateral information that may be of use for other purposes than the direct one of the study itself. Such collateral information naturally contains much of value as to conditions, for example, in Table 6, Article 166, a time study to determine profitable division of labor, in the remarks opposite Operations 1, 2 and 3, the cause of low efficiency is noted as an unadapted condition, incorrect location of the truck containing the raw materials; and opposite Operation 10 is noted the unadapted condition of poor location of the piles of material delivered from the operation. In investigating the conditions in connection with the selection of the point of attack it may be necessary to make some studies expressly to reveal unadapted conditions. Such a study would usually be like that of Table 12, Article 202, to which its purpose is similar but more specialized.

Some conditions are capable of investigation and analysis by other means. I have investigated routing by marking lots of material conspicuously, following them through the process and recording their movements. The conspicuous marking is to enable the observer to make full use of his time by following up a

large number of lots at once. If reliable records of the movement of material in process exist, the same thing can be done more efficiently from the records, especially if the movement can be traced on drawings instead of having to walk over the plant to do it. The power plant can be thoroughly investigated by means of a scientific test. Other apparatus is capable of investigation in the same way. The practical limit to the use of such tests is usually that of expense.

As indicated in Articles 12 and 13, the statements of the minor executives as to their troubles also contain much valuable information on conditions.

The above sources of information are available at the very outset of betterment work. As Records and Planning and Despatching are developed, other sources are opened up.

Any cases of extraordinarily high or low efficiency, as shown by the service cards, the planning department should report at once to the chief of staff, and he should have them investigated promptly in order to learn the facts while those unrecorded are still fresh in the memories of the people concerned. A case of very high efficiency may have been due to the chance occurrence of some very favorable conditions. Immediate investigation may reveal what they were; and it may then be possible to produce them regularly, and thereby to make an improvement, not only of the actual, but also of the standard performance. Very low efficiencies should, of course, be investigated so that their causes may be ascertained and the unfavorable conditions removed.

The mere effort to plan will reveal unadapted conditions as obstacles to the plans. Note should be made of these obstacles and, if it is not desirable at once to

undertake their removal, they should be recorded for attention later, as recommended in Article 143.

151. Mention has been made in Article 104 of the file of Exception Cards to be kept in the Cost Department. As fast as planning and despatching is installed this becomes a complete record of all delays, except those of the most trifling character, throughout the plant, together with a statement of the nature of every delay and, if possible, of its cause. At regular intervals, at least once a month, a clerk should go through this file and should summarize the money loss due to every nature and cause of delay, and should report the summary to the Chief of Staff.

If any nature or cause of delay has attributed to it any considerable loss, the Chief of Staff ought to investigate through the proper members of the staff organization the possibility of preventing or, at least, reducing the amount of such delays in the future; and if any such means are found to be feasible, he should set about putting them into effect through both the line and staff organization concerned.

152. After the card index of equipment, recommended in the chapter on Records, is installed, it will be found that the history of every piece of equipment therein contained will show whether any equipment suffers from a continually recurring cause of trouble, or whether any cause of trouble affects large numbers of machines. This record is therefore the place where unadapted conditions with reference to equipment will make themselves apparent. With a view to discovering and remedying such conditions of importance, routine measures should be installed with reference to the card index of equipment like those recommended above for the file of Exception Cards.

153. The following adaptations of conditions are important in every plant, no matter what the nature of the business is:

Location of plant
General cleanliness and good order
Manufacture of as few varieties of product as possible
Permanence of type and style of product
Suitability of product to equipment and of various articles of product to one another.
Volume of production equal to plant capacity
Orders in size or quantity for efficient manufacturing
Efficient equipment
Readiness of equipment for use when and where wanted
Routing (See Article 149)
Accurate knowledge of physical quantities involved in the processes
Readiness of personnel for service when and where wanted
Division of labor
Safety of personnel
Ventilation
Lighting
Warmth
Work height
Suitable hours of work and periods of rest
Suitable materials
Clean, orderly and properly arranged storage
Standardized location of stores
Prompt and accurate inspection
Supply of material when and where wanted

There are other adaptations which are taken care of by the application of the other principles of efficiency, and there are still other adaptations which are peculiar to every particular case.

154. *Location of plant.* Harold V. Coes sums up this matter in a systematic analysis reproduced on the following pages: [1]

[1] "The Rehabilitation of Existing Plants," *The Engineering Magazine,* July, 1915.

Factors governing the location of an industrial plant.

(1) Proximity of raw material market
- a—Rail service
- b—Water service
- c—Supply

(2) Proximity to consumers' market
- a—Large cities
- b—Rail service
- c—Water service
- d—Advertising value or influence of plant
- e—Competitors

(3) Labor market
- a—Character of labor and supply
- b—Percentage of unemployed females (women and girls)
- c—Percentage of unemployed boys (above legal factory age)
- d—Price of labor—cost of living
- e—Specialization of labor
- f—Influence of climate
- g—Associations or unions

(4) Power
- a—Price and character of fuel (coal, gas, oil)
- b—Hydro-electric or water power
- c—Central station

(5) Influence of climate
- a—On labor
- b—On product

(6) Utilization of waste products
- a—Disposal of waste products
- b—Market value of waste products
- c—Cost of disposing of the same, if the material is unmarketable

(7) Perishability
- a—Raw materials
- b—Finished product

(8) Freight rates
- a—On raw materials
- b—On finished products

(9) Legislation, regulation or ordinances
- a—State legislation (corporation laws, taxes, employers' liability)
- b—Municipal, town, or county regulations or ordinances (taxes, factory building inspection)

(10) Banking facilities
- a—Size—handling pay-rolls, etc.
- b—Credit
- c—General utility

(11) Site of real estate (city, suburb, country)
- a—Price
- b—Character of soil
- c—Foundations
- d—Cost of preparing site
- e—Floods

(12) Building Materials
- a—Local sand, gravel, etc.
- b—Crushed stone
- c—Brick
- d—Timber
- e—Steel
- f—Cement

As previously noted, manufacturing conditions change and we find when we study the conditions governing the location of an industrial plant that the early industries, particularly in the Eastern States, were located where we find them on account of the dominating influences of Numbers 1, 2, 3, and 4 of the factors shown in the foregoing list. It is evident that Numbers 1 and 2 are readily susceptible to changing industrial conditions as the country develops. We find that 4, 8, and 9 are giving us, in certain cases, considerable concern. It has been noted that different kinds of industries have a tendency to concentrate in particular localities. Among the causes of this concentration are the above mentioned factors. The most important of such factors to be considered are:

1. Proximity to raw material
2. Proximity to market
3. Proximity to labor market
4. Proximity to power

Suppose, for example, for a particular industry, that 1 and 2 have shifted so as to bring 8 into prominence. On the other hand, 3a, 3d, 3e, 4a, 4b, 9, and 10 are more advantageous to the industry or business in question than to competitors to whom 1 and 2 are more favorable, and in which 8 is of minor importance. It is apparent that 1 and 2 exercise less and less influence as the problem of transportation becomes less important economically. In consequence 3 and 4 become predominant factors. This deduction leads us to the study of the ways and means of minimizing the effects of 1 and 2

and of accepting the advantages that accrue from 3, 4, 9, and 10 by means of proper plant adjustment, reorganization, and rehabilitation. Let us see, then, if we can strike a balance of the various factors entering the problem that will help us to intelligently decide the question.

By drawing up a list of questions that are a result of analyzing the situation and ascertaining the facts, we find that practically fourteen items cover the important factors relating to the present plant location and that seven items suffice for the consideration of a new location.

PRESENT LOCATION

1 P. L.—What is the investment in the present plant?
2 P. L.—How much of it is *fixed capital?*
3 P. L.—What proportion of 2 P. L. could be recovered by the sale of the property?
4 P. L.—How much additional property would have to be acquired to properly develop the plant?
5 P. L.—What would the investment be?
6 P. L.—Is the labor market satisfactory?
7 P. L.—Is the raw material market satisfactory?
8 P. L.—Are the shipping facilities adequate?
9 P. L.—Can 8 P. L. be made so?
10 P. L.—Can the present buildings be suitably altered to adequately serve the business?
11 P. L.—What will 10 P. L. cost?
12 P. L.—Can the present buildings properly be made a part of a logical comprehensive development of the plant?
13 P. L.—What are the fixed charges of the present plant?
14 P. L.—What is the production cost per unit?

NEW LOCATION

1 N. L.—What will the land for a new site cost?
2 N. L.—What will the buildings cost when completed and ready for occupancy?
3 N. L.—What will be the fixed charges on 1 N. L. and 2 N. L.?
4 N. L.—How much will 1 N. L. and 2 N. L. be reduced by 3 P. L.?
5 N. L.—Will 6 P. L., 7 P. L. and 8 P. L. and other considerations be sufficiently improved to effect production cost 14 P. L.?

6 N. L.—Will the production cost per unit be lowered?

7 N. L.—Will the margin between the selling price and production cost pay 3 N. L. plus a sinking fund and leave sufficient profit to warrant the undertaking?

If we tabulate the facts brought out in any given case (such for instance as the assumed one) the mind can more readily compare them and can intelligently weigh the information with a view to securing the proper balance.

Obviously nothing more than a summary of a question of this magnitude can be given in the treatment of the general subject of Efficiency.

155. *General cleanliness and good order.* In a plant of considerable size one of the factories was conspicuous for its efficiency. The orderly state of everything connected with it also at once attracted attention, and it was as markedly superior in this respect to the rest of the plant as it was in efficiency.

The superintendent in this factory told me that he had served in the United States Navy, and that he could never get over "wanting to keep everything ship-shape."

The cleanliness of his factory and his having a place for everything and everything in its place was not the only cause of high efficiency, for he was thoroughly versed in the technique of the difficult processes under his control and very attentive to them; but certainly neatness and good order were among the causes of that efficiency.

156. *Manufacture of as few varieties of product as possible.* An ideal plant for the development of a very high factory efficiency is one in which a single product is made in very large quantities. The truth of this is so well known to manufacturers that argument is unnecessary.

Unfortunately, selling efficiency is opposed to the attainment of this condition. It is very much easier to sell the customer just what he wants than anything else, and it may be necessary to give him his way to a considerable extent to sell him anything at all.

If the sales department could have its way without limit the product would be varied endlessly, but it does not pay to sell what cannot be manufactured at a profit any more than it pays to manufacture what cannot be profitably sold. Hence, in practice, manufacturers are forced to a compromise, in which the problem is to reconcile efficiency of manufacturing with efficiency of selling.

By varying assemblies of only twenty-six letters, we get the immense variety of vocabulary of the western European languages, and there is no limit to the possibilities of additions to them.

Out of a small number of standard parts an immense variety of assembled product can be built.

There are many concerns struggling with the problem of reconciling manufacturing and selling efficiency who have never given this axiom thorough application.

In order to do this, it is necessary to go over the product thoroughly, and to reduce all the component parts to the smallest possible number of standard pieces.

A stock of these standard parts must then be maintained, and the stock must be covered by a card index perpetual inventory or stock ledger (see Article 113) which should carry maximum and minimum limits for every part. Suppose that each of three assembled articles, which we may call 1, 2, and 3, contains one of part A. Suppose that fifty of article 1 are ordered from the factory. The planning department should

send requisitions for the parts, or worked materials, to the stock room; the latter should deliver them to the assembly department, and the planning department should send the latter an order for fifty of article 1.

Confining our further attention to part A, the stock clerk would credit the fifty parts on his inventory and would strike the running balance.

If the stock were not drawn down to near its minimum limit, he would not order any new parts; but if the minimum were approached, he would call on the planning department to order from the shop enough parts to bring the stock up to the maximum. If the part were used in three different articles, the number of parts ordered would average three times what would be made in single lots for one article.

The application of the above methods is not limited to parts which are absolutely identical. Parts which differ somewhat from each other and different sizes of the same part should be designed so that they will go through as many as possible of the same operations with the same set-ups. These parts can be combined in manufacture to the increase of factory efficiency. Every part should carry on its card in the perpetual inventory, or stock ledger, a reference to the parts with which it combines in manufacture, so as to enable the stock clerk to take advantage of these combinations in ordering.

For example, returning to the illustration used above, suppose that part A of articles 1, 2, and 3 goes through operations I, II, III, and IV. Suppose that part A′ of articles 6, 8, and 10 can be designed so as to go through operations I, II, and III with the same set-ups that are required for those operations by part A of articles 1, 2, and 3, but that it undergoes operation

VII instead of operation IV. The perpetual inventory card of Part A would bear a note, "Combine in ordering with part A′ of articles 6, 8 and 10." The part A′ card would bear a similar reference to part A.

When the stock clerk got the supposed requisition for fifty of part A and found that its stock was drawn down low enough to justify him in ordering more, he would look for the cross reference on its card and would then see the card for part A′. Supposing that he found that he had on hand 76 of part A′, and that its maximum limit was 200, he would then call on the planning department to order from the shop 124 of part A′ to put through operations I, II, and III with the lot of part A ordered at the same time.

The above methods of design in standard parts, standard parts carried in stock, perpetual inventories with maximum and minimum limits and cross references, and planning, furnish a means of reconciling a large variety of finished product and good efficiency of selling with manufacturing the minimum variety of parts in large quantities and good factory efficiency.

157. *Permanence of product as to type and style.* There is hardly anything that causes more inefficiency in a factory than frequent changes of the product. Such changes throw everything into confusion, with resulting wastes that do not need explanation. In a plant in which this sort of thing was carried to an extreme, I once found two of the employees who were best acquainted with the product discussing and unable to decide whether a supply of a certain part that was in stock could be used in the assembly of the latest model or not. The only member of the organization who could tell was a member of the sales department who was away on the road.

If I may judge from my own experience, a large proportion of such changes are needless and represent merely weak yielding to the whims of some customer, or to the fancied necessities of some salesman, and can be stopped at once by the firm action of the General Manager, and in no other way.

Of course there must be change, otherwise there will be no progress, and there ought to be a continual search for beneficial changes. If the plant is of any size, these matters ought to be referred to an Experimental and Research Department (see Organization Diagram, Figure 1, Article 66) to work out and standardize before they are put into the manufacturing departments.

If the recommendations of the preceding section as to design in standard parts are carried out, and changes are first thoroughly tested in a separate department, a necessary change can be localized on a few parts with the minimum of effect on the manufacture of the article as a whole, and consequently with the minimum loss of factory efficiency.

The problem is closely akin to that of repairs and special work, which is discussed in Article 121. There is, of course, the type of plant which does only repair and special work. This is, in effect, a special department for all its customers, serving them by keeping the inefficiencies of special work out of their plants, and taking them upon itself. Standards for such a plant must necessarily be lower than for a manufacturing plant, and its costs must be correspondingly higher. The work of such a plant may be just as profitable as that of a manufacturing plant, provided it is able to get prices proportionate to its costs; and this depends largely upon its ability to show its customers what its costs really are and that its prices are reasonable.

There are also plants which make articles for personal use, in whose sales frequent changes of style are an immense factor. Such plants must seek efficiency by other means than permanence of product. Their profits depend also upon getting a proper price, which with them depends largely upon skillful advertising and salesmanship; but it is important for them to know their costs in order to know what prices to demand.

Therefore, to plants of both these types good cost keeping is of extraordinary value.

158. *Suitability of product to equipment and of various articles of product to each other.* In the engineering industries very great attention is given to this adaptation; but as I have seen other industries, their attention to it is altogether inadequate.

The matter of suitability of product to the equipment will come to a head in the costs by articles which, as recommended in Articles 133 and 134, should be periodically reported to the General Manager. If any article is not suited to the equipment and costs are correctly kept, the fact will be bound to show in an excessive cost of that article. Tracing back by the methods described in Article 134 will show where the trouble is.

Subordinate officials are likely to know already through the more detailed records that come to them, but it may be necessary for the matter to come to the attention of the General Manager for all that, because it rests with him, or perhaps even higher up, to say what the product shall be. That being decided by higher authority, the factory executives have to make it as best they can.

Suitability of various articles of product to each other is discussed in Article 156, but it has many advantages other than those brought out there. For ex-

ample, in a plant manufacturing any kind of hollow ware, the ability of different articles to "nest," that is, to stow compactly inside of one another, has a great effect on the efficiency of space both in storing and in shipping.

Evidently, if a concern manufactures more than a very few articles, the maximum suitability of any part or article to the equipment and to the rest of the line can be obtained only by careful consideration of this very point in connection with its design. Such consideration is very much facilitated by having among the records a complete drawing of everything regularly made.

On this point H. B. Lange[1] says:

> To appreciate the field of opportunity for standardization it is to be noted that many works organizations maintain engineers who make this work their sole function. It has been often demonstrated that on repetitive work low costs can be accomplished by reducing all product to a unit basis without reference to the final assembly. Where working within limits of allowable variations it would seem advisable to draw one part only on sub-division of a drawing sheet—preferably of letter sheet size—with a separate part list and an arrangement drawing giving the assembly information. Proper filing and classification of prints or drawings assist in selection of parts already in use and in revealing parts of similar character which might be consolidated for standard adaptation. The cost of drawings is negligible compared with accrued benefits. Mounting prints on straw-board and keeping them filed when not in use is economy. Standardization can be furthered by a showing on a letter-size sheet the part with a list below of the differing dimensions.

Further, unless the business is very small or the product consists of a very small variety of articles, adequate consideration of this point will be impossible for people who have much else to do. This calls for

[1] *Journal of American Society of Mechanical Engineers.*

the inclusion of Design under the Experimental and Research Department shown in the Organization Diagram, Figure 1.

159. *Volume of production equal to plant capacity.* The presence in a plant of definite equipment and personnel means the ability, at maximum efficiency, to perform a certain amount of work. Fortunately, the efficiency varies only slowly as the volume of production varies on each side of the maximum point, but evidently a point must be reached where any more production means a lowering of efficiency due to poor workmanship and spoiled work as a result of hurrying, and if production falls below what will fully employ the equipment and personnel, idleness both of workers and of machines results.

The working force, of course, can be reduced, but must then be correspondingly increased when normal production is resumed, so that this deprives the employer of the efficiency due to permanence of personnel.

There are two main fluctuations of volume of production. One is seasonal, and the other is due to the general condition of business.

Seasonal fluctuations are partly due to natural causes, like inability to obtain raw materials except at certain seasons, as in the canning industry, and are partly due to the habits of the trade. The former fluctuation must usually be accepted, but up to date equipment may be able to reduce it, if not to remove it. Speaking of seasonal fluctuations, Dennison says:

> The effect of weather conditions in other trades as in the candy trade, for instance, has been considerably helped by the refrigerating process; and other technical means can be found to avoid these other difficulties, if we are only persistent enough about it.

As to trade habits, several determined attempts to correct the seasonal fluctuations due to them have been successful.

In estimating financial results of betterment work in Table 15, Article 383, 5 per cent of the sales price at maximum production was deliberately set aside for the benefit of the customer. If the seller does this (or something similar) he can demand of the buyer that in order to obtain goods at the lower price the latter shall give him such notice as will enable him to smooth out the seasonal fluctuations due to trade habits.

Fluctuations can, of course, be reduced by manufacturing to stock in dull times and selling from stock in good times, but this involves a risk of which those in business control must judge for themselves.

However, if the manufacturer by giving the customer a share in the benefits of increased efficiency can induce in the latter a preference for his goods, he can manufacture to stock with the greater confidence.

Even if the employer cannot avoid fluctuations of volume of output, he can minimize the resulting inefficiency by making his organization elastic.

Necessarily the skilled worker must be kept, if possible, because he can be replaced only with difficulty. The unskilled worker can be hired off the street at any time. M. W. Alexander estimates the average cost of changing an employee as shown in Table 5, page 164.

Evidently cost as well as facility of change requires that changes should be confined to Group D as far as possible, and then to Group E. This can be effected by recruiting according to the method outlined in Article 35, and by practicing division of labor in such a way as to separate the skilled from the unskilled operations, as illustrated in Table 6, Article 166.

TABLE 5

COST OF CHANGING ONE EMPLOYEE.

	Class of Employee New Employees						Re-Hired Employees
Group	Hiring	Instruction	Wear and Tear	Reduced Production	Spoiled Work	Total	
A	$0.50	$7.50	$10.00	$20.00	$10.00	$48.00	$10.00
B	.50	15.00	10.00	18.00	15.00	58.50	20.00
C	.50	20.00	10.00	33.00	10.00	73.50	35.00
D	.50	2.00	1.00	5.00	.....	8.50	5.00
E	.50	7.50	1.00	20.00	.....	29.00	10.00

Group A comprises highly skilled mechanics who must have practiced their trade for a number of years in order to attain the required degree of all-around experience and proficiency;

Group B comprises mechanics of lesser skill and experience who can acquire an average degree of proficiency within a year or two;

Group C contains the large number of operatives usually known as piece workers, who without any previous skill or experience in the particular work can attain fair efficiency within a few months, somewhat depending on the character of the work;

Group D includes all unskilled productive and expense laborers who can readily be replaced in the course of a few days; and

Group E is composed of the clerical force in the shops and offices.

As there shown in the Standardized Operation, the stock sawyer's work can be separated into those operations which he must do himself because they require skill, or cannot be done by another without interfering with the sawyer, and certain unskilled operations which any strong laborer can do for him. When there is plenty of work a laborer can be employed, and he and the sawyer can work according to the Standardized Operation. When there is insufficient work, the laborer can be laid off and the sawyer can do all the work.

Similar methods can be applied to many manufacturing operations, and by so doing a large amount of elasticity can be imparted to the organization. That

is, it can be expanded and contracted on short notice and with minimum injury to its efficiency.

Team work in the organization comes to the front as a palliative of the evils due to fluctuations in the volume of production. On this point, Dennison says:

> One influence that may work toward the betterment of seasonal irregularities is the closer relation between the manufacturing and the selling ends. This we have found, ourselves, to be extremely valuable. Letting both of these departments run without intimate connection caused very considerable difficulties, whereas, when we brought them together and made each serve the other, we found large improvements in getting orders out earlier for delivery, anticipation of orders wherever possible, etc.

160. *Orders in size or quantity for efficient manufacturing.*

Let S=time to set up a certain machine.

Let T=time to perform the operation on one piece.

Let N=number of pieces machined at one set up.

Then, if there is no loss of time outside of setting up,

$$\text{Efficiency of use of machine} = \frac{NT}{NT+S}.$$

The relation of N to Efficiency is plotted in the curve OB of Figure 4 for the case in which S equals T. Evidently, in any case as N increases, the curve continually approaches but never gets quite up to the line of 100 per cent efficiency, and reaches a point, in this case B, where the gain from further additions to the size of the order is very slow.

Usually, however, there are inefficiencies whose amount is about directly proportionate to the size of the order, for example, those due to spoiled work. The inefficiency due to these losses would be approximately expressed by a straight line OF. The intercept, KL,

represents at any point the net effect of the number of pieces on the efficiency. At that value of N for which the tangent to OLB is equal to the tangent of the angle made by $OKMF$ with the axis of N, the intercept has its maximum value; and if the number of pieces in the order exceeds this, the final efficiency will be decreased.

In many plants these considerations may be of no importance; but in some cases, like those shoe factories in which orders are sent through in certain definite numbers of pairs and must bring through an exact number, and in which any spoiled work causes considerable trouble and delay, the size of order which will produce maximum efficiency is of much importance.

What this size of order should be can be determined only by sending through orders of various sizes and keeping records of the results. It is impossible to keep all the conditions, except the value of N, even approximately constant until betterment is very far advanced; but very much earlier it may be possible to determine a working approximation to the most efficient size of the order. This is the more feasible because a glance at Figure 7, Article 341, shows that the intercept KL will vary only slowly on each side of the maximum point.

161. *Efficient equipment.* This is the condition against which an American plant is least likely to offend. Having plenty of equipment and having it up to date is a hobby of American manufacturers.

In fact, the national sins are to scrap equipment while it is still valuable, thereby burdening the plant with a perpetual fixed charge for the interest on the value written off, and to have too much and too big and expensive equipment, leading to idle equipment time and excessive equipment burdens.

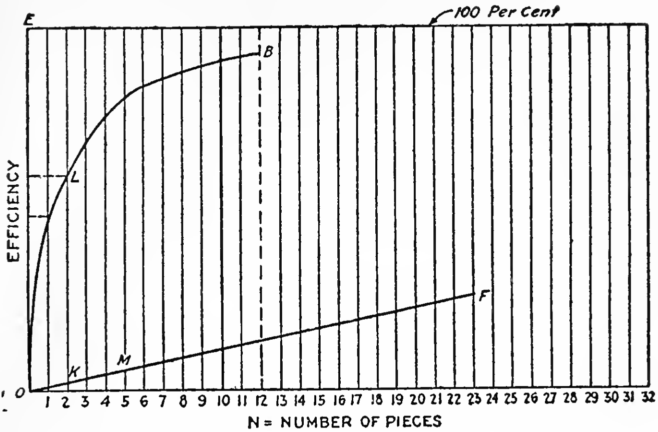


FIG. 4. EFFECT OF SIZE OF ORDER ON EFFICIENCY

As Harrington Emerson says, "The American plant is usually over-equipped and under-supervised."

Usually, on undertaking betterment work, the effort should be to increase the efficiency of what is already in the plant rather than to hasten to newer and better equipment.

In connection with the efficiency of equipment, the excellences of electric drive are so old a story that they require nothing more than mention here; but it is well to call attention to the fact that the choice between alternating and direct current, then among the different classes of motors of each kind, then the choice between single and group drives, and finally the selection of motors of capacity to give the best efficiency, presents a problem of so much complexity that it can be properly solved only by the joint labors of two experts, one to decide what the machines need and another to determine the motors to supply it.

162. *Readiness of equipment for use when and where wanted.* In order that equipment shall be ready for

use when and where it is wanted, it is necessary that the purpose for which it is to be used and its preparation for that use should be planned. This point is covered by the general application of the principle of Planning and Despatching.

Where jigs, fixtures, dies, and other small tools are used, it is necessary that there should be efficient tool-room service. In a certain large plant the punch press department had a tool room, but no tool-room service. The first result was that the efficiency of use of space in the tool vault was very low, so that it was apparently full, though really containing much waste space. Consequently, dies were stowed in the work room, under the benches, and in every possible place. Because of difficulty of finding dies when they were wanted, and of the lack of advance attention to their condition, machines were delayed excessively for set-ups. This decreased the capacity of the shop and resulted in congestion of its floor space with work waiting. This further decreased the efficiency of the department and its capacity, and thereby increased the congestion.

This is an example of the fact that inefficiencies act and react on each other, each to increase the gravity of all the rest. Conversely, if a little gain in efficiency can be made at one point it tends to improve others as well and to make all further progress easier.

Division of labor usually requires that the care and maintenance of equipment should be entrusted, not to the men who run it, who should be specialists in operating and should not be distracted from it, but to men having special skill in maintenance and repair work. This properly applies even to such matters as the care of belts and of small tools.

Advance attention must also be given to the condi-

tion of the equipment, so that trouble may be prevented instead of waiting for it to happen and then making repairs.

In my personal experience as a sea-going engineer, anticipative inspection of ships' machinery as a means of preventing break-downs was familiar, and I have often wondered that managers ashore do not give more attention to it for that purpose. Apparently, the possible serious consequences of a break-down at sea caused marine engineers to adopt this practice in advance of managers on shore.

In Article 139 are mentioned card records which give the complete history of every piece of equipment of any importance. These records furnish the data on which to base anticipative inspection which, as Knoeppel puts it, should be organized along the following lines:

Each piece of equipment should be considered as a unit.

As to each unit, the factors likely to cause trouble should be determined.

Each unit should have a record card on which is recorded its complete history.

For the various factors determined upon as requiring attention, limits as to time should be set for inspection purposes.

Men should be delegated to look after this anticipative inspection.

These inspectors should be supplied with inspection reports upon which to record their findings. These reports should be made out from the record cards covering the particular factors to be looked into, and sent to the inspectors. This would constitute an advance planning for this sort of work.

The inspectors should take the inspection reports, make the inspections called for, note the conditions, advise as to troubles developing, and state what should be done, and when.

These reports should be taken and the information contained thereon entered on the record cards.

Repairs to the units as made should be entered on the record cards, showing date and nature of work done.

Because the time limits at the start will be more or less arbitrarily determined, it will be found as the work progresses that many of them will need adjustment. For instance, a factor may have a time limit of eight days, when every five days will be found to be the best limit. Another might have one of four days and every two weeks would be found to be sufficient. Adjustment of limits is simply a matter of analyzing the information shown on the record cards.

Cost of repairs should also be entered on record cards.

163. *Routing.* The financial importance of good routing varies greatly. In laying out a new plant it should, of course, be given careful attention; but in an old plant the amount of actual money loss due to poor routing should be at least approximately determined before expensive re-arrangements are undertaken. For example, in a tannery all wet processes, like soaking, removal of hair and flesh, and washing, were located in the basement. Between steps of the wet processes occurred the dry operations of splitting, pressing, and shaving, which also required better light than could be afforded in the basement. For these reasons these operations were located on the floor above. This necessitated the moving of the hides several times up one floor and back again to the basement. This was evidently inefficient, but on investigation was found to involve only a negligible money loss. The reason for this was that the plant was so small that the elevator man could do all the trucking involved. As his presence was necessary for other reasons, no appreciable sum of money could be saved by improving the routing. Evidently if the business should increase so as to require a force of truckmen, this problem would change; and, in general, the bigger the busi-

ness, the greater the refinement that can profitably be effected in all details.

The Ideals in designing the routing for a plant are stated by Coes as follows:

1. Minimum transportation of material from the raw to the finished state.
2. Proper relationship of all buildings with regard to the plant as a whole.
3. Unity for future extensions: that is, if a plant be determined whose departments are all properly located with respect to an ideal routing, then future expansions and future additions must preserve this same relationship.
4. Maximum light and ventilation and proper sanitary arrangements.
5. Economical development of entire property to its ultimate capacity.

The amount of expense and trouble that is warranted in attaining these ideals depends largely upon the permanence of the enterprise. Many American plants are now engaged in work which, it is to be hoped, is only temporary. They are adapted for distinctly other lines of work and expect as soon as possible to return to them. Naturally the wise course for them is to make the best of such routing as they have for their present temporary work.

The importance of the first ideal and the possibility of achieving it depend very much upon the character of the industry. Continuous processes on only a small variety of product, for example, sugar refineries, flour mills, steel-rail mills, packing houses, textile industries, cement mills, paper mills, wooden-box factories, and car-wheel and pipe foundries, offer the best chance for routing with minimum transportation; and in such industries of considerable size, very excellent examples of it are to be found. Even in continuous processes a

marked difference in the conditions required by two successive operations may make transportation preferable to close sequence of location, as in the case of the small tannery above cited.

At the other extreme are many industries that consist principally of assembling operations, little machinery being employed, and that of small size, the entire business consisting of small self-contained production centers. Floor space is the principal requirement and, within limits, the building may be any shape. In some of these industries the density of the workers is almost the only limiting factor, so much so that legal restrictions are in force in many states to regulate the congestion possible in these callings.[1]

In the case of some assembling operations a marked change has recently developed. The prevailing practice is to locate the assembly at a fixed point, to bring all the parts to that point, and there to assemble them by the labors of a very few workers. Automobile engineers have recently worked out much greater specialization and division of labor by a radical change to what they call "progressive assembly." In this the principal element of the assembly is started from a fixed point to follow a definite route along which are assembling stations. At every station highly specialized workers add to the asembly only one or a very few parts. Very remarkable gains in efficiency and reductions of costs have been made by this method. It has been very highly developed by the Ford Motor Company, and many of its progressive assemblies are described in great detail by Arnold in "Ford Methods and the Ford Shops."

Evidently the fundamental gain by this method is that due to specialization, or division, of labor.

Progressive assembly is coming into use to some ex-

[1] Kimball, "Principles of Industrial Organization."

tent in foundries, as the construction of a mold is evidently an assembly; and the limits to the application of this method cannot yet be foreseen.

It thus appears that in many cases of assembly, routing, instead of being a negligible factor, is one of the first importance and to be perfected to the utmost.

Intermediate between continuous processes and usual practice in assembly operations, there are all degrees of importance of routing and of possibilities of perfecting it. Close to continuous processes are plants, like shoe factories, which carry on a continuous process, but one subject to continual change due to change of styles and complicated by working on a considerable variety of product; and near the other end are jobbing metal-working shops, in which good routing is desirable, but very difficult to attain on account of the lack of repetition in the processes.

In any case the following information is necessary in order to design correct routing:

Complete list of operations in sequence;

Necessary capacity at every operation in order to balance the equipment throughout;

Number and size of machines necessary at every operation in order to attain the designed capacity;

Floor space needed about every machine;

Requirements of every machine as to drive, illumination, ventilation, and safety; and

Space needed for gangways, storage, inspection stations, and administrative offices.

The possibility of solving the problem satisfactorily depends upon the existence of definite information on the above points. Often this is very difficult to obtain. When a problem of this kind comes up, the value of the file of service cards by machine numbers recommended

in Article 103, and of the schedules explained in Article 108, is very great. In the absence of such records or equivalent the only way to get the information is to assemble the general knowledge contained in the memories of the shop executives, make studies of the progress of work through the plant, and then check the information derived from each source by that derived from the other.

In a continuous process the design of the routing as a first approximation would consist in arranging the necessary machines and clear spaces in the order of sequence of operations within the limits imposed by the building site. The next step would be to modify the design so as to meet the needs for storage, power, light, ventilation, departmental organization, and safety; and to separate successive operations whose respective conditions conflict, as in the case of the tannery above cited. The flexibility of electric drive as to location, and its non-interference with light and ventilation, indicate its convenience in designing a plant lay-out. The reader is referred to Arnold's "Ford Methods and the Ford Shops" for a description of routing in a continuous process designed to practically ideal perfection.

Where any considerable variety of product is made, especially in an intermittent process, the sequence of operations is apt to be so different for the different kinds of product that any arrangement of equipment on this basis must be a compromise, and often a very difficult one. On the other hand, the variation of the sequences makes it convenient to have machines that perform the same kind of work located together in order that workmen with special skill in their operations may be kept with them. By this means, flexibility

of planning is obtained because, due to the similarity of the machines located together, any workman of that class can work with any machine and any machine and any man can be used on any article. This also tends to efficiency of supervision, since a foreman or straw boss has to manage only closely related operations situated near one another. When a sequence of operations is very difficult to arrange, these considerations lead to an almost complete abandonment of the attempt and to the arrangement of machines in groups according to their similarity, with usually a little general service equipment, like drill presses, emery wheels, and vise benches, attached to every group. In this case, efficiency of movement of materials, which will probably not be attained anyway, is deliberately sacrificed to obtain the assured efficiency due to flexibility of planning and to specialization of labor and of supervision.

164. *Accurate knowledge of physical quantities involved in the process.* One still finds temperatures, humidities and other such quantities left to the unaided judgment of the workman on the job. This sort of thing leads to uncertainty as to the results of processes and to unreliable product. The remedy is, of course, the measuring of such quantities by instruments, so that physical quantities determining processes can be controlled to standard amounts in the light of exact knowledge. The use of automatic recording instruments for this purpose has additional advantages, as stated in Article 106.

165. *Readiness of personnel for service, when and where wanted.* A very few concerns are applying to their personnel the anticipative inspection of "regular, systematic periodic physical examination of the entire body, such as is applied to ordinary machinery."

This inspection is followed up by advice, instruction, and treatment as the need appears, in order "to raise the general level of fitness, well being, and efficiency." This work is done by a medical staff.

Aside from such anticipative inspection and treatment this adaptation follows naturally from the application of the principles of Personnel, Organization, Fair Deal, Discipline, and Planning and Despatching, and does not require further discussion at this point.

166. *Division of labor.* Time studies, or even casual observation, in most plants will show that any skilled worker is performing not only his skilled operations, but also others, like trucking, sorting and arranging materials, lifting weights, and so on, which can just as well be done by unskilled labor. In such a case, the efficiency is low because part of the work is done by higher priced labor than is necessary.

In order to improve the efficiency, it is necessary that the unskilled operations should be separated from the skilled, and that each should be assigned to workers of the proper class. This results in Division of Labor.

The worker on each class of operations then becomes a specialist in a narrower field than before and goes on to develop the higher skill due to that closer specialization, so that Division of Labor further increases its efficiency.

In order to obtain this increase of efficiency, it is often profitable to separate operations that are equally skilled, so as to obtain the benefit of closer specialization on all of them.

On the other hand division of labor increases the dependence of every worker on the service of others and, if this service is required very irregularly, the difficulty of providing it reliably without having some

of the workers wait in idleness between times, may be so great that division of labor may be impracticable.

Confining our attention to the considerable number of operations, in which division of labor is practicable, it is apparent that in every case it increases the amount of handling of the material, and the monotony of the occupation. Monotony increases fatigue and thereby lowers efficiency. Hence division of labor is not without its losses, and if it is pushed too far, the losses may overbalance the gains.

TABLE 6. TIME STUDY IN A FURNITURE FACTORY

Order 2342 Article—1231
Operation—Cross cutting (stock sawing)
Material—Chestnut { 39 per cent. Sound wormy No. 1; 56 per cent. " " No. 2; 5 per cent. Culls. }
100 per cent.
Dimensions of lumber—14 ft. × 9 in. average, × 1 inch
Parts—Back rails, end rails, inside rails, inside facings, center rails, center drawer fronts, back rails
Machine—Cross cut saw 82
Workman—298, Wutt

Operation	Time (minutes) Actual	St'd	Remarks Time as given per board for main cycle only
1. Walk to pile of boards....	.066	.06	Standard assumes lumber on truck located near machine from which sawyer can pick up board at its middle, instead of dragging it endwise off the pile
2. Pick up board...........	.07	.036	
3. Return to saw with board.	.07	.072	
4. Place board on table of saw	.011	.011	
5. Saw board..............	.134	.134	
6. Throw kindling off saw table into barrel.........	.021	.015	Kindling saved and sold as by-product
7. Handle and inspect board.	.406	.406	
8. Measure board..........	Inappreciable		
9. Assemble cross-cut pieces on table of saw..........	.057	.057	
10. Walk to cross-cut piles....	.133	.089	Standard assumes cross-cut piles more conveniently located, as is possible
11. Place cross-cut pieces on piles....................	.16	.16	
12. Walk to saw from cross-cut piles....................	.033	.03	Average total for 11 boards separately observed = 1.09
Total main cycle.......	1.141	1.07	

In any proposed division of labor, the question therefore arises as to how the operations should be divided and whether the division will pay. This question can be answered by means of a time study which, in case of minute sub-division, will have to be a time-motion study. Table 6 gives a time study made for this purpose in a furniture factory.

TABLE 6. TIME STUDY IN A FURNITURE FACTORY (CONTINUED)

Orders 364, 365, 376
Article—487
Operation—Cross-Cutting (Stock sawing)
Material—Chestnut, Sound Wormy, No. 1
Dimensions of Lumber—10 ft. × 7.9 in. average, × 1. in.
Total linear ft. original = 2935
Machine—Cross-Cut Saw, 82
Workman—298, Wutt
Part—Panel and top cores

Operation	Time (minutes) Actual	St'd	Remarks Overall Operation
Take off apron	.4	.4	
Oil saw	.31	.31	
Dust saw table	.57	.57	
Cross-cut 85 boards	....	....	
22 @ 1.288 in 28.34 minutes			
21 @ 1.19 in 25. "			
23 @ 1.436 in 33.08 "			
4 @ 1.04 in 4.16 "			
4 @ 1.808 in 7.23 "			
11 @ 1.423 in 15.65 "			
85 @ 1.335 in 113.46 "	113.46	81.	Standard = .951 × 85. (.951 is estimated from study of the main cycle, allowing for difference in length of boards. This allowance was based on a number of other studies of cross cutting)
Mark pieces for benefit of later operations	.59	.59	
Read job order	.16	.16	
Talk to rip sawyer	.98	.00	
Under instruction of Foreman	.21	.21	
At toilet	2.69	9.249	10 per cent. of total time allowed for rest
Eat	.78		
Delayed by rip sawyer getting in the way	1.23	.00	
Total: By addition of stop watch items above	121.38	92.49	By addition
Total: By standard watch	122.28		

By providing the cross-cut sawyer with a helper to do the unskilled work these standards are attainable:

STANDARD OPERATION OR CORRECT METHOD

Main cycle

Sawyer	Time (Min.)	Helper	Time (Min.)
		Walk to pile of boards.....	.06
		Pick up board.............	.036
		Return to saw with board...	.072
		Wait for sawyer...........	.165
Place board on saw table...	.011	Place board on saw table...	.011
Handle and inspect board...	.406	Walk to cross-cut piles.....	.089
Measure board (inappreciable)........	.000	Place cross-cut pieces on piles........	.16
Saw board.................	.134	Walk to saw from cross-cut piles........	.03
Throw kindling into barrel..	.015		
Assemble cross-cut pieces on table of saw..............	.057		
Total..............	.623	Total..............	.623

Overall Operation

Cross cut 85 boards........	53.	Provide 85 boards and carry away cross-cut pieces from same....................	53.
Auxiliary operations.......	1.67	Dust saw table............	.57
Rest.....................	6.07	Wait for sawyer...........	1.1
		Rest.....................	6.07
Total..............	60.74	Total..............	60.74

The above indicates that standard times for a cross-cut sawyer with helper can be reduced to $60.74 \div 92.40 = 66$ per cent. of standard times now set for a cross-cut sawyer working alone.

Comparison of Cross-Cut Sawyer Working Alone with Cross-Cut Sawyer with Helper, Based on 100 Standard Hours of Cross-Cut Sawyer working Alone.

Sawyer Alone at 100 per cent Efficiency		Sawyer and Helper at 100 per cent Efficiency	
Total hours...............	100	Total hours...............	66
Wages to Sawyer @ .25....	$25.00	Wages to Sawyer @ .25....	$16.50
		Wages to Helper @ .185...	12.20
Bonus to Sawyer..........	4.17	Bonus to Sawyer..........	4.71
Total wages and bonus...	29.17	Total wages and bonus...	33.41
Burden on machine $\$.40 \times 100$...............	40.00	Burden on machine $\$.40 \times 66$................	26.04
Burden on labor $\$25. \times .65$...............	16.25	Burden on labor $\$28.70 \times .65$.............	18.68
Total cost..............	$85.42	Total cost..............	$78.49

In order to reach a decision, it is necessary first to determine the proper standard time for the sawyer alone; then to determine the Correct Method, or Standardized Operation, for the stock sawyer and helper working together; and then to determine the standard time for the two working together. It can be assumed that, as the general application of the Principles of Efficiency takes effect throughout the plant, actual time on the operation will, on the average, equal the standard time. The standard times determined then furnish a basis for estimating the cost of the operations by either method of working.

It will be noticed that the total cost of wages and bonus is increased by the proposed division of labor; but that, when burdens are included, the total cost is reduced by the division. The reality of saving on the burden would probably depend on whether there was work enough to occupy both sawyer and helper to full capacity. If there were, so that output would be increased by employing the helper, the overhead would be carried by a larger volume of product, and there would be a real saving in burden. If the output could not be increased, the saving in burden would probably be fictitious. This indicates that the division of labor should be practiced if the plant were working at full capacity; that the profit of the division would decrease as volume of production fell off; and that, if the plant were working at or below 66 per cent of capacity, it would be more profitable to use the sawyer without a helper.

In other words, if the plant were working 60 hours a week at full capacity, it would pay to divide the cross-cutting operation by giving the sawyer a helper; but if production should fall off to the capacity of a

full crew at 40 hours per week, it would be cheaper to run 60 hours and let the helper go, than it would be to keep him and run 40 hours, unless a material reduction of overhead expenses could be effected by working the fewer hours. See also Article 159.

In general, of course, division of labor can not be carried far where there is either a small volume of work or a large variety of work, because it fundamentally requires a sufficient amount of repetition so that a worker's whole time can be employed in a narrow specialty.

167. *Safety of employees.* In the matter of minor injuries to operators, a punch press without safeguards is one of the worst machines there is. The last few years have seen the fitting of safety devices to most of these, in common with other machines. I have never seen a punch-press safety device which did not add one or more motions to the main cycle of operations and therefore require an increase in the standard time for the job. Nevertheless, experience shows that the production of punch presses does not fall off permanently from the addition of safety devices.

What is the explanation of this apparent paradox?

In the days of unguarded punch presses, a man would take a job as an operator and would not work long before he or a shop mate would lose a finger. A little of that usually sickened him of punch-press work and he would hunt for another job. If he was fortunate, that was the last of punch-press work for him; if not, he might come back to it under compulsion, only to leave it again as soon as he had a little money ahead or another accident had frightened him.

The result of this was that the only permanent punch-press hands were a low class of men who from

some defect, mental, moral or physical, were unable to rise above that kind of work; and they had the low efficiency inevitable to men of that kind. With the great decrease of danger, a corresponding improvement has taken place in the quality and efficiency of the operators. The new and efficient man does the work, including the operation of the safety device, in no longer time than the old inefficient man required, without that loss of time.

This is a concrete illustration of the fact established by general experience, that it pays to afford all reasonable protection to workers. The importance of a permanent personnel, which comes up again and again in these articles, is a sufficient reason for guarding against change by accident or sickness. See Article 159, Table 5.

Faurote lists the following principal causes of accidents:

1. Defective structures.
2. Defective machinery.
3. Insufficient room.
4. Absence of safe-guards.
5. Uncleanly conditions.
6. Insufficient light.
7. Lack of good air.
8. Unsuitable clothing.
9. Carelessness.
10. Bad mental condition of workmen.
11. Ignorance.
12. Lack of co-operation.

Except absence of safe-guards and unsuitable clothing, these all require attention in other connections also in any effort for increased efficiency; for example, insufficient room comes up for attention in the design of the necessary clear spaces in solving the routing problem.

Bad mental condition of the workmen is to a considerable extent removed by the application of the principles of Personnel, Fair Deal and Efficiency Reward, as will be seen by reference to the chapters on those principles. Besides this, one's mental condition is greatly influenced by the conditions under which he works, especially by warmth, light, and ventilation.

Closely related to protection against accident, is protection against infection. The latter requires cleanliness, good light and ventilation, a sanitary supply of drinking water, and the prompt treatment of all wounds, no matter how slight. Other measures like the detection and elimination of infected persons, may be necessary under special circumstances; but these are usually taken care of by the local Board of Health. See also Article 165.

All workers should be positively required to report to some designated person for first aid immediately on receiving even a scratch, in order to avoid the danger of infection. The common practice of administering first aid at the same place where applicants for work are received, either the foreman's or the superintendent's office, should be discontinued. The sight of blood and first aid applications is distinctly discouraging to an applicant for work, and may scare away a desirable employee. Concerns of any size commonly employ a nurse and provide a first aid room and seem to find the practice profitable.

168. *Ventilation.* Tests and universal experience have clearly shown that one's power falls off with fatigue. The general relation between working time and working power is shown in Figure 5. It goes without saying that a tired worker can not attain a high standard of performance.

The characteristic effects of fatigue are produced by poisons deposited in the blood by the tissues broken down by work. These poisons are eliminated by oxidation in the lungs. Hence any deficiency in the supply of fresh air hastens fatigue and thereby lowers efficiency.

Fortunately window ventilation is practicable in a temperate climate during a large part of the year, and the workers themselves generally leave the windows open and get plenty of air at such seasons; but in winter the ventilation of work rooms, especially if they are at all densely inhabited, is often bad.

It has been abundantly demonstrated that good ventilation pays, but in the absence of artificial methods for use in cold weather, much more than is usual can be accomplished by window ventilation. Some attention to the matter and to the direction and force of the wind will usually find a means of changing the air in a room, admitting sufficient fresh air and at the same time so diffusing it that there will be no objectionable draft. However, success in this is not to be expected without some Instruction of foremen and other shop executives, and of the workers themselves.

Beside ventilation for breathing purposes, machines which throw off finely divided matter, like dust or fine grit, and processes which give off poisonous fumes like carbon bisulphide from some cleaning processes, should be covered with exhaust hoods through which the objectionable matter is sucked away and discharged where it will be harmless. This practice is so general that it probably requires no further comment, and it is required by law in many states.

169. *Lighting.* If any one wants to get a quantitive measure of the value of good illumination, let him make

two time studies, one in good illumination and the other in poor illumination with all the other conditions the same. The results will be sufficiently convincing as to the value of light.

The Ideal in illumination is uniformly diffused light, sufficient for clear vision without eye strain, but free from glare.

The attainment of these ideals with maximum efficiency well repays the competent counsel of an illuminating expert, and can not be adequately treated in any other way.

Even without advice, one can guard against such sins as low hung incandescent lights in plain bulbs, in some places blinding the eyes of the workers with an intense direct glare, and at others making any refinement of measurement or of work impossible by throwing conflicting shadows across the object of vision, from whatever angle it is viewed.

It has also proved true that where an adequate supply of natural light is brought into service, men work more safely and cheerfully than where the best artificial light is employed. When new buildings are under construction, usually no extra expense is involved in providing sufficient window space.[1]

Freedom from glare with adequate illumination by natural light, gives the preference in the northern hemisphere to north light from a high angle, leading naturally to saw-tooth roofs where that construction is practicable. Ribbed glass offers the best solution of the problem on other than north exposures.

Permanence of good natural illumination requires that the windows should be kept clean. This means some expense, but it is cheaper to clean the windows than to do extra work occasioned by semi-darkness.

[1] N. F. A. Safety Bulletin.

Beside illumination of working places, safety requires that halls, entries, and passages, especially the top and bottom of stairways, should be lighted; but only enough light for men to see their way about is needed in these places, and that is considerably less than would be required for work.

170. *Warmth.* The necessity for sufficient warmth to safeguard health and to enable workers to use their fingers efficiently is so obvious as not to require discussion. If I may judge from my own observation, American plants are sufficiently heated except in the most extreme winter weather. Usually it does not pay to go to much expense to remedy a condition which occurs only seldom.

It may be well to point out, in passing, that a steam-power plant, exhausting into the heating system, can give both power and heat at a very low cost.

171. *Safety, Ventilation, Light and Warmth.* Coes sums up the situation with reference to these four conditions as follows:

> The most able administrator, with the most efficient scheme of management, is tremendously handicapped by the physical characteristics of poorly arranged, poorly lighted, badly ventilated and carelessly sanitized buildings.
>
> In reality there is no excuse now for poorly lighted buildings, old or new. There is sufficient evidence at hand to prove that pure air and unretarded sunlight increase working efficiency. Operatives who can see well, work more accurately, spoil less material, work surer and faster. If furnished with good light and air, they have more reserve energy. In most cases, the attendance is better and more constant where the workers have good, clean, pleasant and congenial surroundings. They work 54 or 60 hours a week, as the case may be, and appreciate good sanitary facilities and pleasant surroundings.
>
> There are factories where the light is so bad, ventilation so atrocious, sanitary arrangements so villainous, that it is

impossible to understand how their employees are retained at all. On inquiry it will be found that they do not retain them for any length of time—that is, good ones. Any man or woman who has red blood in his or her veins would leave—they cannot stand it—their self-respect will not tolerate it. The class that stays does not have the sense or energy to leave and are not worth having at any price. The output per operative would be ridiculously small compared with standard conditions.

We are beginning to realize the effect of these things not only on the industrial plant, but on the community itself. We cannot afford to breed eye troubles, tuberculosis, etc., in factories simply from lack of proper conditions. Society cannot tolerate it.

Mr. Kimball in his "Principles of Industrial Organization," says, "It is impossible to overestimate the value of abundant light, heat and ventilation. These things were looked upon in former days only as luxuries, and the cold, dark, bad smelling shops so common a few years ago were in most cases mistaken efforts in economy. It is true that modern building construction has made the lighting of factories a comparatively easy matter, but it is important that it be kept in mind that light, heat and ventilation pay dividends.

"In times past great care was taken that clerks on small salaries were comfortably housed and they would not have been expected to do good work unless so cared for, while the high-priced mechanics were too often expected to produce good results in spite of all sorts of physical discomfort and inconvenience. There is no difference between the psychology of office and of shop. Workmen can naturally produce more and better work in well ventilated and well-lighted rooms, and while this would naturally be accomplished by improved physical surroundings alone, it is largely added to by the consequent improved mental outlook."

A certain motor-car company in the Middle West noting the changed conditions of the new plant over the old, states: "After operating in our new plant for several weeks, we find that the improved working conditions have so increased the efficiency of our labor as to enable us to reduce our working day from 10 to 9 hours without diminishing the pro rata amount of production."

Similar instances could be given for almost every industry that has either constructed a new plant or rehabilitated an old one.

172. *Work height.* Two quotations from Arnold's articles on "Ford Methods and the Ford Shops" will suffice for this important condition. He says:

> In all instances it is of first importance that the workman should stand (or sit) upright. A stooping posture very soon tires the workman and greatly reduces his efficiency. The Ford engineers attach so much importance to this "work high" condition that they are now placing a great number of gray-iron raising bases under various machine tools, particularly under presses, to bring the work at such a height that the workman can either stand or sit erect, any stoop being now well known to cause a marked reduction in the worker's output.

173. *Suitable hours of work and periods of rest.* Four thousand or more years ago, the experience of employers in Babylon taught them that their workers did more in seven days by working six and resting one, than they did by working every day. The institution of one day's rest in seven became so firmly imbedded in Semitic industrial tradition, that Moses incorporated it in the Ten Commandments, and gave it the sanctity of religion.

Thanks to Moses, the occidental industrial world received the tradition ready made and rested one day in seven. China never learned the lesson and has worked seven days a week. I suspect that the progress of the Sabbath-keeping nations, and the stagnation of the ever working nation, is more than a coincidence; that the Chinese, by refusing to stop work one day a week and get the fatigue poisons out of their blood, destroyed their capacity for original thought and consequently for progress, just as it would become impossible to keep up steam, if the stoke hold were never cleared of ashes.

At the beginning of the industrial revolution due to the invention of machinery, factory owners worked their employees always for long hours and sometimes for sixteen hours a day, probably in imitation of the hours of agricultural laborers of the period; but work in factories was so much less healthful than work in the open fields, that factory workers visibly deteriorated under the conditions and the bad effects on the industrial population became so apparent that there has been a slow and reluctant, but continual, reduction of the hours of work. Thus far experience has justified these reductions by increase, instead of the dreaded reduction, of output. If any one knows exactly what hours of work will give the greatest output per worker under any given conditions, he ought to speak out for the benefit of the world. See Article 217. It is to be noted, however, that there is no general movement by employers for a return to former long hours.

Short periods of rest distributed through the body of working hours, also increase efficiency, varying greatly according to the particular circumstances.

The low wages for which women work and their greater fitness for operations requiring deftness, cleanliness or delicate finger work, indicate the efficiency of using them for the work for which they are peculiarly suited. However, the employer of women who desires to attain maximum efficiency must recognize the disabilities to which they are subject and must treat them accordingly. Care of women workers, adequate heat, light, ventilation, and sanitation of their work places will decrease the effects of these disabilities. Women require more rest than men, and while a man can rest on a pile of boards and in the presence of his fellows,

women often require comfort, quiet, and privacy for adequate rest. Progressive concerns which employ large numbers of women are realizing more and more the necessity of providing rest rooms for their special use, in many cases accompanied by the continual service of a nurse or other woman attendant. The gradual increase of installations of this kind indicates that those who have tried them find that they pay.

The whole matter has so close a relation to the determination of Standards that further discussion of it is given in the chapter on that principle, Article 216.

174. *Suitable materials.* Some discussion of this condition is given in Chapters III and XVIII, Higher Common Sense and Selection of the Point of Attack.

The amount of money paid out for materials is shown by the accounts, and is therefore fully appreciated by the management. The costs occasioned by defective and unsuitable materials can be determined only approximately and with difficulty, so the natural tendency is to buy cheap materials. They may also be the cheapest in ultimate cost; but the chances are that they will not be.

The best way to guard against losses from unfit materials is to determine what qualities are needed for maximum efficiency, to express those requirements in written specifications, and to enforce the specifications by inspection. Of course materials of minor importance would probably not repay this expense; but it is certainly warranted in the case of materials which are used in large quantities and of those which, though used in small quantities, may, like lubricating oil, have an important effect on the efficiency of the whole plant. The preparation of specifications is a part of the determination of Standards.

Not only is the quality of raw materials important, but also the quality and condition of worked materials as the latter pass from operation to operation. Very great loss may be caused by allowing wrongly worked or damaged parts to pass along and have more work put on them before they are detected. At the best this leads to excessive cost for making good the damage, and sometimes leads to scrapping the entire article in an advanced state of manufacture. Here again the remedy is prompt and efficient inspection.

175. *Clean, orderly and properly arranged storage. Standardized location of stores.* This condition hardly needs discussion or even explanation. One might think that it did not require even mention, if he had not seen the astonishing violations of it in actual practice.

176. *Prompt and accurate inspection.* Morse says:

Products should be bought as far as possible according to specifications agreed to by all parties interested, including the Purchasing Agent, and they should be inspected by men *independent of all parties interested.* The use of standard specifications is comparatively common, the proper following up of these specifications by intelligent inspection comparatively rare. Such being the case it is unfortunately true that the bidder on high-class product is at a distinct disadvantage. This is not a theoretical statement, but a hard fact, which is causing many efficient manufacturers of high-class product serious concern.

Is the Purchasing Agent an unbiassed judge of the quality of product? No. Unless inspection is independent and competent as outlined above, he is only mildly interested in the quality of the product.

This statement is made in a tolerant spirit. Purchasing Agents are human. Their success is measured by the money which they save. Bids on the more important purchases are scanned by an executive and old prices are compared with new. Money is a tangible measure of success, while departmental complaints in general terms are only a negative proof of failure.

In accordance with these requirements, the inspection department is represented in the Diagram of Organization, Figure 1, and in the discussion of Organization, as under no line authority below that of General Manager—the chain of command running, General Manager, Chief of Staff, Chief Inspector, Inspector.

The inspectors of work in progress have two important functions: to prevent damage, and to determine the amount of product for which the worker is entitled to credit, and which is fit to pass on to the next operation.

In order to perform the first function, the inspector must see the job promptly at the beginning of work. The foreman very commonly performs this function, and there is no objection to his doing so, provided he is sufficiently free from other duties and is otherwise qualified to do it efficiently. This of course calls for an obvious modification of the organization.

If the despatch board is used, as explained in Chapter VII on Planning and Despatching, the cards in the stand-by pockets show the inspector just where his attention will be required for this purpose, while the two copies left at the despatch board, of the cards actually in work, show him approximately when it will be wanted. If it is not desirable that the inspector should look through the pockets of the despatch board, the despatcher can do that and make out separate orders to the inspector, what he is to inspect and when.

The determination of the number of pieces for which the worker is to be credited involves making a record of rejections, and this is discussed in Article 121.

It is desirable that inspection should be made immediately upon the completion of the work, and that the parts should pass on at once to the next operation;

but this may not always be possible, and is sure not to be if the inspector requires considerable bulky or heavy equipment for the proper performance of his work. In the latter case there must be an inspection station easily accessible to the work places, and the work must be delivered there as soon as possible after the completion of work on it.

If inspection at the work place and immediately at the completion of the operation is practicable, it may be planned and despatched similarly to the other inspection. If the work has to go to an inspection station, the ultimate ideal should be that inspection would be planned and despatched the same as any other operation; but my own experience is that it is troublesome to get this going and that the installation of departmental planning and despatching ought not to wait for it.

In order to get departmental planning and despatching going, the planning sub-principle of the Reservoir (See Article 123) may be applied to the inspection station. The departmental planning then takes up the work every time the inspection station finishes with it and plans it on to the next time it has to go there, at which point the departmental planner drops it from his plans until it again emerges from the inspection station. Even at the outset, the departmental planners should indicate to the inspection station the order in which work is wanted from it. As long as the matter is being handled in this way, the central planning office must leave corresponding discretion to the departmental planners.

In some cases every piece must be inspected, if bad work is to be effectively prevented from passing on. The problem of inspection is then very difficult. If the

work will bear the cost, a sufficient inspection force may be provided to examine every piece; otherwise about the only suggestion of general character that can be made is that workers may be offered a small bonus for discovering and rejecting faulty pieces that come to them. The inspection then becomes a by-product of the direct work of people who have to handle every piece. Usually if this plan is followed, the rejections by direct workers ought to be passed upon by an inspector, and the latter's approval ought to be necessary to make the rejection valid. The inspector ought then to make out the record of rejection, for which see Article 121.

177. *Supply of material when and where wanted.* Where the problem of routing has been very well solved, so that operations are located in their proper sequence, and successive operations near one another, the workers may simply hand the materials along from one to another; and a very small trucking force may move the work, as it is completed, from the last operation of one department to the first operation of the next.

In some cases where large amounts of material are handled in this way, it has been found profitable to provide smooth rails or ways, along which the material can be pushed, with a minimum of labor to the next operation. In some cases this labor can be further reduced by providing smooth slides, inclined at slightly more than the angle of friction of the material. By raising the material very slightly above the working level, the delivering operator places it in the upper end of the slide, whence it is carried by gravity to the person who receives it. This method is, of course, limited to materials of which the units are neither very heavy

nor easily injured. In extreme cases and those in which the time of every operation has been very closely determined, the materials may be moved past successive operators on some form of power-driven conveyer, every operator doing his own work as the material passes him. In intermediate cases, the material may be set on a runway in which rollers are mounted. Each worker then easily shoves the material along the runway to the next. This is especially convenient if the operations are such that they can be performed without removing the work from the runway. A slight downward pitch of the runway in the direction of travel will often make movement still easier. These methods have been worked out in great refinement in the Ford plant.

In any case there is the possibility of considerable labor saving in the movement of materials by up-to-date equipment, most of which is probably too familiar to require even mention. In my own experience I have noticed a lack of appreciation by plant managers of those forms of trucks which permit of unloading in mass, without disturbing the load, and without the necessity for handling the units of the load in detail.

Where the routing is less perfect, the movement of materials must receive the attention of the planning department, and in any case this must be given to the initial movement of materials from the store rooms to work rooms, and to the movement of dies, jigs, fixtures, and other tools, from tool rooms to machines and back again. These matters are discussed in the chapter on Planning and Despatching, except the movement of material from operation to operation. Here again the despatch board gives advance notice of what is wanted; and the move-man, or boss trucker, may

either consult the despatch board directly or, if that is not advisable, the despatcher can consult the board and make out the necessary move orders.

An intermediate case occurs where the movement is too complicated to be reduced to a simple flow from operator to operator, but still is so simple that the move-man can readily learn it by rote. All that is necessary then is for the move-man to learn the routing, and move the materials finished at one operation immediately on to the next.

It has been found that direct workers lose a great deal of time if the work comes to them in an unadapted condition, as when a man has to pick out successive pieces of work from a tangled or disorderly pile, or where parts which have to go to a machine in a certain way are received hit or miss by the operator so that he has to turn them over or around, before entering them in the machine; and that the direct workers also lose a great deal of time if they have to hunt around for a place to deposit their finished pieces. Sometimes automatic arranging or sorting machines may be used to adapt the condition in which the work goes to the operator; and in the Ford plant, the work slides enable many operators to drop their finished work from the hand at a standard point, without any thought. If these methods are not practicable, division of labor can often be applied, at least to adapting the condition of the work as received. The work of adaptation can then be separated from the main operation, and the former may be assigned to cheaper workers, one of whom can probably serve several operators.

178. Beside the general conditions which are listed above, every industry, every plant, every department

and every operation has peculiar conditions of its own. The means of investigating these are the same as those stated in Articles 151, 152 and 153, for the investigation of conditions in general.

179. In connection with operations there are many minor unadapted conditions which in the aggregate cause a great deal of loss. For example, see Table 6, Article 166, "Remarks" Column, opposite operations 1, 2, 3 and 10. It is safe to say that if the sawyer were put on standard time for the operation and received an Efficiency Reward for approximating the standard, he would himself adapt the conditions there noted. When betterment begins, the attention of the efficiency staff is necessarily limited to the big things; and it is important that the workers should be used in this way to adapt minor conditions, by installing standards and starting efficiency reward as soon as possible. However, see Article 310 as to the proper time to start Efficiency Reward. Minor conditions should have the attention of the efficiency staff as soon as more important matters are out of the way, for experience has shown that the direct workers themselves will very seldom accomplish thorough adaptation.

180. About twenty years ago, a technical paper was published in which the author bemoaned standardization as the death knell of progress. As we look back over the time, his fears seem somewhat amusing. If one concern had a monopoly, it might achieve standardization, allow it to degenerate into stagnation, and refuse to make further progress. Sometimes a concern does that, whereupon mortification sets in, and in due time the remains are buried. Meanwhile the world of industry moves on, making of adaptation not an obstacle to, but an instrument of, progress.

Chapter X

STANDARDS

181.

ON the China coast twenty years ago, in the absence of any Chinese coinage except the valueless "cash," money of all countries circulated and was so mixed with counterfeits and clipped and plugged coins, that every business house of any importance kept an expert judge of money called the "shrof" and would accept no money until it had been passed by him. When the shrof passed a coin, he stamped his mark on it and minor traders judged of the value of coins by their shrof marks. Every financial transaction of importance required the services of the shrof with his expert judgment, and weighing and stamping of all money that changed hands. Think of the clumsiness and inefficiency of such methods compared with those to which we are accustomed! We little realize that William III delivered the English-speaking peoples from similar inefficiencies in dealing with their debased and clipped currency by appointing Sir Isaac Newton a seventeenth century Scientific Manager of the mints of the realm; and that, to the latter's determination of accurate standards of the coin and his institution of milled edges in order that any alteration of these standards in circulation might be easily detected, we owe the

result that our money now serves easily and with commercial accuracy as a standard of value.

182. In business, the determination of standards is becoming a matter of more and more importance. The time is not far distant when the business manager, if he is to succeed, will have to know, when he burns coal to generate power, how many horse-power hours he ought to get for every pound; if he uses cloth to make garments, how many yards should be cut for every one; if he employs labor, how many hours of work should go into every job. That we have been able to get along thus far by only guessing at such standards is due to the fact that we have been wasting vast natural resources with but little competition.

183. The mere known existence of a standard is in itself a great stimulus to efficiency. A certain office manager determined standards for work on typewriters. No other measure of betterment was introduced. Also no attempt was made to drive the typists. Nevertheless they knew that the office manager knew what constituted a fair day's work. The result was an immediate increase of the amount of work done by every typist, except one, whose performance the standards showed to be already about 100 per cent efficient.

No matter how conscientious one may be, no matter how determined he may be to do his best, unless he can compare his actual achievement with a proper standard, he will almost always let down from what he might do. Human nature seems to be made that way. When, beside having a standard, all performance is regularly and systematically compared with it by means of Records, when all inferior performance is corrected by the application of Instruction and, if need be, by Discipline; and when all good performance is regularly and

systematically encouraged by Efficiency Reward; then the effect in increase of efficiency in many actual cases has been nothing short of marvellous.

184. The application of Standards to the executives, and to the business as a whole, is especially important. An example of the practical working of this is given in Article 53.

Expenses will not decrease of themselves. The general manager first sets a standard, to which expenses must come down. The realization of standard cost then becomes a function of the factory manager and of the superintendents, foremen and assistants.

For this purpose the expenses are segregated into groups. These will vary somewhat with circumstances, but Table 7 is offered as a suggestion.

TABLE 7

Direct Labor	Appropriation	Standard Allotment
Department 1	$75 000	$63 000
" 2	50 600	41 300
" 3	36 000	28 100
" 4	46 800	46 000
" 5	42 500	34 180
Total	250 900	212 580
Direct materials	260 000	234 000
Total Direct Labor and Materials	510 900	446 580
Direct use of Equipment	63 180	60 021
Indirect labor:		
Department A	9 000	6 480
Other	3 000	2 340
Indirect materials	40 000	32 000
Maintenance	11 820	6 779
Supervision	35 000	35 000
Power, including light and heat	25 000	22 500
Rent	115 000	103 000
Miscellaneous	5 000	5 000
Total overhead expense	307 000	273 120
Total annual expense	817 900	719 700

The column headed Appropriation gives the total of each cost as estimated from the accounts to be sufficient for the expected production and existing efficiency, while the column headed Standard Allotment does the same except that the assumed efficiency is 100 per cent.

The determination of existing efficiencies is a vital feature of this process. It is discussed in Chapter XV, Determination of Efficiencies.

The responsible executives should not be allowed to exceed their appropriations without very good reason, and they should be given Efficiency Reward in proportion as they succeed in reducing their actual costs toward the standard allotment. In Articles 129, 130 and 132, the responsibility of executives for various costs is discussed.

It is desirable that these methods should be started as early as possible in betterment work. There are two ways of producing efficiency. One is to bring it down from above by such methods as are here suggested; and the other is to bring it up from below by minute time-study work, adaptations of conditions, instruction of workers, and so on. The former method gets results of considerable value much more quickly than the other, and it is therefore desirable to bring down as much efficiency as possible from above as quickly as possible. Also if the executives receive an Efficiency Reward for reduction of expenses, they are much more apt to favor the work and thus to enable efficiency to be brought up from below more quickly than if they opposed it.

185. When standards are set for direct workers, it is desirable that they should be permanent unless conditions change, and it is *imperatively necessary* that

they should not be made more severe. The executives are usually men of sufficient intelligence and in close enough touch with the management to permit standards to be set for them on the basis of fairness only; and with the distinct understanding that a standard that is unfair to the owners will be changed in their favor, just as much and just as promptly as it would be changed the other way if it were unfair to the executive. On this account and because of the importance of getting standard allotments and efficiency reward based upon them into effect as soon as possible, methods may be employed to rough out standards for the executives that would be objectionable if applied to the direct workers.

Take for example, indirect materials, in Table 7. It would take a lot of work and considerable time to set a standard for this expense by any methods of accurate scientific analysis. For this purpose we may set a standard for it by the method of comparative records. That is, we may look back over previous records of the business and find that about the lowest annual expense shown for indirect materials on about the estimated production is $32,000; or we may know that some other plant of the same kind and about the same size spends $32,000 per year for this purpose. Also we may apply general knowledge; that is, we may know that it is a rare thing to find an efficiency of better than 80 per cent for indirect materials, and knowing that the plant in question is not particularly efficient in this respect, we may feel sure that it ought to be able to effect a 20 per cent reduction in its annual bill. For any or all of these reasons, we may feel justified in making the standard allotment for indirect materials $32,000. Obviously, the standard thus set is likely to

be grossly inaccurate, but if it will quickly lead to a reduction of somewhere near $8,000 in annual expenses, its accuracy is of minor importance; and if we actually get our indirect materials for the year for $24,000 we can reduce our standard allotment for the next year.

If we were to set a standard for a workman in such fashion and he should make a serious effort under the incentive of efficiency reward, he would probably beat the standard handsomely, because comparative records themselves usually show only inefficient performances. If we should then make the standard more severe, he would probably quit trying. In fact, making standards more severe after they have been beaten is the principal cause of standing pat on piece rates.

However, this rough and ready way of setting standards for executives has an important bearing on the forms of efficiency reward that should be offered them, and therefore comes up again in Articles 285 to 288.

186. Returning to the general subject of Standards, all knowledge and every means of acquiring it are properly used for their determination, but the time study is the instrument most used and most important. It is capable of such valuable use, not only for the determination of Standards, but throughout all management, that it requires careful explanation.

187. There are as many different ways to make a time study as there are objects sought in so doing. It is necessary, therefore, to have clearly in mind just what information is wanted, and to make the study accordingly.

188. Table 8 (page 206) shows an example of a time study made for the purpose of determining standard times for a wide range of jobs on the wood-working machine called a joiner.

In order to advance betterment work rapidly, it is necessary to derive the standards from as few studies as possible, and it is therefore necessary to analyze the work, if possible, into elements which will recur in every job. The column headed Operations in Table 8 shows these elements in this case.

The analysis into elements may go to as great refinement as necessary. The greater the refinement, the longer the time needed to make the study; and this is an important consideration, where there are, as usual, very many standard times to determine. The subdivision into elements should therefore not be carried further than is necessary to accomplish the purpose sought.

Gilbreth's method of having work done in front of a moving-picture machine with a large and finely divided clock dial included in each picture accomplishes the most minute analysis thus far attained. This method is of great value where the cost of the operation studied is enough to warrant the necessary expense in carrying to the utmost the application of the principles of Instruction and Correct Methods. This case usually occurs only where an operation is performed very often by large numbers of workers.

Usually the stop watch with face divided into hundredths of a minute, is close enough to accuracy, and allows fine enough division into elements, for every commercial purpose; and it is the instrument usually employed for time-study work.

189. As an example of an analytical time-motion study for the deduction of general formulas, Table 8 is given, and in it and throughout these articles, those elements which recur again and again, thus constituting a definite cycle, will be called the "Main Cycle."

The elements in Table 8 are not stated in the order of performance but are assembled according to that variable upon which their total time of performance depends. Under "variables," each is stated and an algebraic symbol for it is assigned. First there are four elements which are done once per every group of pieces handled and machined together. As the sum of the standard times for these elements is .131 minutes, we get the term *.131 N* of the formula for the time of main cycles.

Next, under "Operations" in Table 8, are two elements of time, whose total in any job depends upon the lengths of cuts taken and upon whether these cuts are with or across the grain. These result in the terms *.003 L* and *.005 l* of the formula.

Then follow two elements which are done once per every group of edges handled and machined together, which give the term *.017 E* of the formula.

The elemental standard times given in Table 8 are the average of several such elemental standards determined each for a different kind of work. Again, each of these elemental standards was derived from several observations of actual times for the performance of that element. The method of determining standard time from actual time is discussed in Articles 198 to 200.

Elemental actual times can not be observed continuously, because no one can handle stop-watch, pencil, and paper fast enough to observe and record such short times without interruption. One must first analyze the work into its elements; and then, as an element occurs, one must time it, and then allow other elements to go untimed, until he has recorded the observation and is ready to make another. One must, of course,

make several observations of the actual time of every element. If the first few that are taken closely approximate uniformity, one may be satisfied with not less than three observations. If they differ much, one must continue to observe until any new reading produces only a negligible change of the general average from its previous value.

To make sure that there has been no substantial error in the determination of elemental actual times, and also that enough of these have been observed to obtain fair average values, it is a good plan to let the stop-watch run completely through several main cycles, and thus obtain values of its total time independently observed. For example, in Table 10, the elemental actual times total .897 minute as the actual time of one main cycle; while the average time of eighteen main cycles observed in total was .889 minute. Where an agreement as close as this is found, the observations of the elemental times may be taken as near enough for practical purposes.

TABLE 8

EXAMPLE OF ANALYTICAL TIME-MOTION STUDY FOR THE DEDUCTION OF GENERAL FORMULAS

The main cycle was analyzed into the following:—

OPERATIONS and STANDARD TIMES

Time per handling

$$\text{Number of handlings} = \frac{\text{Number of pieces}}{\text{Number machined together.}}$$

	Minute
Pick up pieces from truck of new work / Move pieces to table of machine	.059
Lay pieces onto truck of finished work	.047
Turn to truck of new work	.025
Total time per handling	.131

TABLE 8 (CONTINUED)

Time per Inch Cut

With grain	.003
Across grain	.005

Time per group of edges handled and machined together:

Handle and inspect pieces between cuts	.011
Inspect after final cut	.006
Total time per group of edges	.017

VARIABLES

Let N equal $\dfrac{\text{number of pieces}}{\text{number machined together}}$

Let L equal total number of inches cut with the grain

Let l equal total number of inches cut across the grain

Let E equal $\dfrac{\text{total number of edges to be machined}}{\text{number of pieces machined together}}$

Then time of main cycles for job in minutes equals
$.131N + .003L + .005l + .017E.$

The average time in minutes for the elements was determined by only three time-motion studies.

The number of pieces to be machined together was set by the judgment of the foreman, taking care to make the number large enough.

Standard times were calculated by the above formula for a wide range of work and for oak, chestnut, poplar, and birch, beside occasional other woods.

These times were put into effect as the basis of standard time and bonus, and proved satisfactory with the following exceptions:

As to one important article, it was necessary to require only one to be machined at once instead of two, as at first required;

Birch proved to be so much more difficult to work than the other woods, that the elements based on lengths of cuts had to be increased; and

On a few parts the operation of joining was found

to involve special elements, for which time had to be allowed; for example, one part had to be placed in a fixture and removed from it after the cut. As all the corrections involved increases of the standard time, they were easily made.

190. The time and labor required to make a time-motion study of the type shown in Table 8, are considerable. Where standard times can be set for a wide range of work from a few studies of this kind, it is efficient to make them; but where the object is only to determine a standard time for some one operation, they are not usually justifiable.

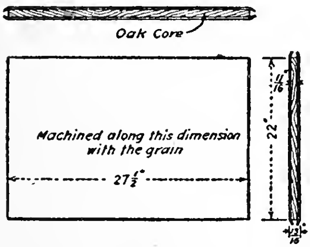
In Table 9 the elemental times are omitted for brevity, and only their sum is given as the standard "time of main cycle for one panel." If the best actual total time of a main cycle independently observed were taken in Table 9 as the standard time for a main cycle, it would be .243 minute, instead of the .2305 obtained by the summation of standard elements. As the average actual total time of such a cycle in the shop was not far from .33 minute, the difference between a standard time of .2305 and one of .243, was altogether less important than it was to get approximate standards into effect at the earliest possible moment. In general, if a fairly good and faithful workman can be observed, and if his method can be accepted as correct, and if a number of his main cycles are timed in total, and then the standard time is determined from these actual times for the main cycle as a whole, on the principles explained in Articles 198 to 200, the result will be found to be practically the same as one reached by a long and careful time-motion study.

On this point Kimball says (Principles of Industrial Organization):

"It should be carefully noted that time and motion study are not essential features of all management. . . . Care must be exercised that the limitations of their usefulness are observed, otherwise, like too highly developed cost systems, the cost of the results will be out of all proportion to their usefulness. There are many kinds of work where refined time and motion study, for the sake of determining principles quantitatively, would be an absolute waste of money."

TABLE 9

Operation—Joining
Material—Oak core, veneered. See sketch
Part—Panel. See sketch
Machine—Joiner 57
Workman—H—— I——, No. 276



One piece handled at a time. No cross grain cut. Machine one edge only, with one cut.

Time of main cycle for one panel by summation of *standard* elements	=.2305 Min.
Average of 5 actual main cycles observed separately was	.333 Min.
One of these totals was .243 and one .265.	

191. A time-motion study of the form given in Table 8 may be justified, not only where a wide range of operations may be covered by a few studies, but also where the variables which enter into the equation for standard time themselves fluctuate over a wide range.

Such a case is given in Table 10. The operation has been analyzed into its elements, standard times have been determined from these; and from this analysis is synthesized the formula given for the standard time to rip veneers for any job.

TABLE 10

Summary of Detail Observations taken at frequent intervals during ....

Order—468
Article—9B-13
Operation—Ripping Veneers
Material / Part — Veneer strips, except the narrow strips for edges, etc. put on in the cabinet room
Machine—Rip saw 102
Workman—357
Average width of strips as finally applied to cores = 6½ in.
Average waste = 13.5 per cent. of cross-cut strips of veneer
Average number of ripped strips = 1.008 (average number of the cross-cut strips from which the former are cut)

Operation	Time (Minutes) Actual	St'd	Remarks
			Main Cycle only All times are per one delivery of ripped veneers
1. Pick up cross-cut veneers from truck..............	.071	.071	
2. Move cross-cut veneers from truck to saw table...	.008	.008	Done once in two deliveries
3. Lay down cross-cut veneers on saw table............	.003	.003	Done once in two deliveries
4. Sort cross-cut veneers on saw table...............	.135	.135	
5. Inspect veneers during process.................	.034	.034	This probably could NOT be so efficiently done by a separate inspection force
6. Pick up cross-cut veneers for ripping, from table of rip-saw.................	.035	.035	
7. Place cross-cut veneers against fence of saw......	.029	.021	
8. Measure veneers during process.................	.062	.06	
9. Adjust saw fence to proper width of cut.............	.165	.162	
10. Move veneers along fence up to saw...............	.009	.009	Actual average feed = 85.9 ft. per min. Standard average feed = 95 ft. per min. Average number of ripping cuts per bunch of ripped pieces handled together = 2.28 Average number of finished ripped pieces per delivery = 3.76
11. Rip veneers.............	.075	.068	
Carried forward	.626	.606	

TABLE 10 (CONTINUED)

Brought forward	.626	.606	
12. Move ripped pieces from behind saw to front of saw table....................	.048	.044	
13. Lay down ripped pieces on table of saw.............	.014	.014	
14. Save usable scrap and by-product.................	.04	.04	
15. Throw out other scrap....	.028	.028	
16. Match up and assemble ripped veneers on table of saw....................	.02	.019	
17. Mark veneers...........	.059	.056	
18. Carry ripped pieces to truck..................	.025	.015	Losses of time were all due to having truck too far from saw
19. Lay ripped pieces down on truck................	.008	.008	
20a. Move from truck of ripped to truck of cross-cut work	.007	.007	
or			
20b. Move from truck of ripped work to saw table........	.022	.021	Include both 20a and 20b in standard time, as the times given are averaged per delivery
Totals	.897	.854	Efficiency = 95 per cent. Average of 18 totals independently observed = .889
			OVERALL Operation
Regular production.......... (Main cycles only)	286.68	272.	286.68 × .95 = 272
Work on other machines.....	.5	.5	
Trucking...................	8.66	8.66	
Other handling of veneers, aside from main cycle........	.33	.33	
Clean up about saw..........	.33	.33	
Get drink..................	.83	.83	
Instruction from foreman....	2.17	2.17	
Fetch needed articles.........	1.17	1.17	
Sort and arrange by-product..	.83	.83	
Study job order.............	1.00	1.00	Auxiliary operations =
Make records...............	2.5	2.5	6.3 per cent. of total
Total................	305	290.42	Efficiency = 95 per cent.

OVERALL standard time in HOURS = $.01775\ (.0321 + .0000818l)\ Nw$
where l = length, in inches, of one surface to be veneered, plus one inch for overhang of rough veneers;
N = number of such surfaces to be veneered;
w = width, in inches of one surface to be veneered, plus one inch for overhang of rough veneers.

In ordinary shop practice, if it were determined to pay piece rates for ripping veneers, either the foreman would set a price on every job by a rough estimate, or, from previous overall records, a price would be set, probably based on either the linear feet, or on the square feet of veneers produced.

As to the first method, the best that can be said is that it would be better than failing altogether to apply the principle of Efficiency Reward, provided that the foreman, in setting his prices, did not violate the principle of the Fair Deal.

As to the second method, it fails to take account of important variables. For example, suppose there were two jobs; one being to cut veneers for 200 cores, each 36 inches long by 27.5 inches wide; and the other for 100 cores, each 61 inches long by 32.5 inches wide; all cores to be veneered on one side only.

Each job totals 1,375 square feet, and the time for the two on a square-foot basis would be the same; but the first requires 3.55 hours, while the second requires only 2.33 hours.

The first job requires the cutting of 2,700 linear feet of veneers; and the second, of 2,660. On this basis, the second job would be allowed 98.5 per cent of the time allowed the first, while it should be allowed only 66 per cent, an error of 50 per cent.

The method of averaging previous overall records also assumes that all jobs on whose records the piece rate is based, were done at 100 per cent efficiency. Since probably all of them were below this, the result is to make the piece rate too high on the average. Under the incentive of piece rates, the workers make earnings that to the employer appear excessive. He then cuts the rates, and the workers retaliate by limit-

ing production; and thus the original intention of piece rates, that of stimulating production, is frustrated.

In a long and complicated main cycle, like that of Table 10, any one cycle will vary greatly from standard. For example, in some cycles, the workman would omit altogether such operations as "4. Sort cross-cut veneers on saw table," and "5. Inspect veneers during process." On other cycles he would be obliged to spend on these operations much more than the average time allowed for them in the standard cycle.

In consequence of this, cycles done in a short time may represent, not cycles that were done at high efficiency, but those in which the worker was fortunate in the brief time that was required for certain elemental operations. Consequently, if on a job of this kind only complete cycles were timed and one of the short ones was taken as the standard, it might represent unusually favorable conditions, and the time set might therefore be too short, and unfair to the worker. Complication and irregularity of the main cycle may therefore require a time-motion study, as the means both of taking account of all the variables, and of setting a fair standard.

This is specific case of the general law: that the more complicated any phenomenon is, the more necessary it is to analyze it into its elements, and to deal with every element separately, in order to be able to understand it and to handle it successfully.

In time-study work, care should be taken to note collateral information that may be of use later. For example, when the data for Table 10 were collected, the question of improvement in methods of inspection was under consideration. Therefore, whenever any of the direct workers under study was noticed to do any

inspecting, the time so occupied was especially noted, and record made as to whether or not it would be better to assign it to a separate inspection force. See Table 10, Operation 5, "Inspect veneers during process." Similarly opposite, "18. Carry ripped pieces to truck" is noted the cause of the loss of time. Such information may be very useful later, as the workman may have to be shown just where and how he is losing time, before he can make a good efficiency on the standard set.

Table 10 exemplifies also the kind of a time study which covers not only the main cycle, but also all operations that are necessary to production. Those not part of the main cycle are called "auxiliary operations," in these chapters. Since time for auxiliary operations must be allowed in setting standards, it is necessary that some studies of this type should be made; but on account of the time needed to observe the auxiliaries, it is desirable that these studies should be as few as possible. This is discussed more fully in Article 208.

It will be noted that among the auxiliary operations, 8.66 minutes are allowed for trucking. The question of allowing a skilled worker to do such things for himself is discussed in Articles 166 and 216.

It is apparent that the nearer the parts into which an operation is analyzed approach absolute elements, the easier judgment on the efficiency of their performance becomes, especially to one who is not familiar with the operation under study. For example, referring to Table 10, one with no particular knowledge of veneer work would find it impossible to judge whether a workman ripped a certain quantity of veneers at reasonable speed; but, after a few observations, he would not find it difficult to judge the efficiency of an

elemental operation like "1. Pick up cross-cut veneers from truck." Hence the greater the importance of accuracy of the standard, the more likely is a time-motion, or even a moving-picture study, to be justifiable.

192. Table 11 gives a study which was made to check standard times previously determined. Some peculiarities of its form arise from the fact that standard times for the shop had been set by another efficiency engineer. Because of failure of the clients to act on his advice, the shop could not attain the standards set, or in fact an efficiency above about 50 per cent on them. Later the clients adopted the measures that had been recommended, and very good efficiencies were made. During the period of failure to attain the standards, they were at first thought to be too severe and I was called in to investigate the matter.

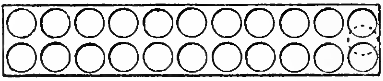
193. Referring to Table 11, it will be noticed that the strips of cloth were not perfectly standardized. Time would certainly have been saved if all the strips issued to the man had been exactly the same, but this could not have been accomplished without wasting materials. In general, of course, some labor will be required to save materials, and the question is only whether the material saved pays a profit on the labor used.

194. In the Remarks opposite the second operation of the main cycle, it will be noticed that an allowance is made for the strip's catching on the next beneath. This represents a loss of time due to an unadapted condition. If the reader will picture to himself what the raw edge of wire mesh cloth cut off by shears is like, he will realize that it would be exceedingly expensive to adapt these edges so that they would not

catch on one another. That being the case, the only thing to do is to allow the workman the time necessary to separate them.

195. TABLE 11

Man {Name, Nesjemm; No. 2048}
Order No. 801 A & B
Operation—Cut cloth
Article—No. 211, milk strainer
Machine—Punch press A 45



Unit standard time as determined by ......, 0.1 hour per 100 pieces

Operation is to blank strainers out of brass-wire mesh cloth as shown by above sketch.

Seven strips out of ten give 22 strainers as shown by full circles.

Three strips out of ten give 21 strainers, the last one being shown dotted.

Main Cycle

Operation	Time (Minutes) Actual	St'd	Remarks on Standard Time Allowed
1. Pick up uncut strip......	.028	.014	Average of all not noticeably slow
2. Move strip from pile to machine................	.062	.057	Man's best three performances; plus allowance for strips catching on next beneath, twice out of 13 times
3. Enter strip in machine....	.086	.086	
4. Place right foot on pedal..	.013	.013	
5. Trip press with foot...... 6. Machine blanks out 1 piece (21.7 times per strip)....	.246	.246	
7. Move strip from hole to hole, lengthwise (9 times per strip)...............	.125	.125	
8. Same crosswise, 10 times per strip................	.228	.190	Average of all not noticeably slow
9. Move from next to last, to last hole, lengthwise (.7 times per strip)..........	.032	.032	Care is necessary to economize material
10. Same, crosswise, .7 times per strip................	.016	.016	
11. Same, diagonally, .3 times per strip................	.025	.025	
12. Move strip to waste box..	.029	.024	Average of best five
13. Drop strip into waste box.	.005	.005	
14. Move hand to pile of uncut strips..................	.016	.016	
Total time per strip....	.911	.849	

TABLE 11 (CONTINUED)

Overall Operation

Operation		Time (Minutes) Actual	St'd	Remarks
1. Blanking strips				
5	One in	.865	.849	
	" "	1.08	.849	
	" "	.835	.849	
	" "	.843	.849	
	" "	.854	.849	
5	" "	.854	.849	
	" "	.865	.849	
	" "	.822	.849	
	" "	1.185	.849	
	" "	.72	.849	Short strip
2. Examining cut pieces (should be unnecessary)..		.15	.000	
3. Straightening end of 1 piece..................		.46	.46	
4. Blanking strips				
5	One in	1.135	.849	
	" "	.875	.849	
	" "	1.165	.849	
	" "	.95	.849	Noticeably slow
	" "	.875	.849	
5. Watching...............		.27	.000	Idle
6. Delayed by torn edge of one piece...............		.5	.5	
7. Blanking				
5	One in......	.85	.849	
	" "......	.875	.849	
	" "......	1.01	.849	Noticeably slow
	" "......	.85	.849	
	" "......	.846	.849	
8. Examining cut piece and die.....................		.67 .78	.000 .000	Should be unnecessary
9. Get hammer............		1.44	.000	Should be unnecessary
10. Hammer die.............		.26	.000	
11. Lay hammer down.......		.05	.000	
12. Hammer die again....... 13. Lay down hammer.......		.26	.000	
14. Blanking one strip.......		.85	.849	
Total for 21 strips = 449 pieces...............		23.974	18.789	
Total for 100 pieces....		5.34	4.19	
" " 100 " .... (according to ......)		6.00	6.00	

TABLE 11 (CONCLUDED)

Time available for rest, changing service cards, handling material between jobs, etc., by ......'s standard less this table........................	.66	1.81
Per cent. of total time available for rest, changing service cards, handling material between jobs, etc. = $\frac{\text{(Next above)} \times 100.}{\text{..........'s standard}}$	11.	30.

......'s standard allows ample time for the job

In this case it was desirable to test the severity of the standards previously set by comparing my own determinations with the previous ones in a few sample cases. That this might give reliable results, it was necessary that my own determinations should be especially accurate. The main cycle was therefore analyzed into its elements and a time-motion study was made. It resulted in a standard time of main cycle per strip of .849 minutes. As a check on this, the total time of twenty-one main cycles was observed separately, and is recorded in the study of Overall Operation. One of these is a short strip and its time therefore could not be taken as sufficient. To require absolutely the shortest or next to shortest time shown for a full length strip would probably also be too severe. We might therefore fix on the third best record for a full length strip, as being a fair standard. This record is .843 minute; and no one could say, even after making a time-motion study, that .849 was any nearer right. Because the time-motion study was made, one has much more confidence than he could have had otherwise that a standard of .849 is about right; but if the only object had been to set a standard time for this operation, one might better have timed the

twenty-one main cycles only, and set the time for one at .843 minute.

196. When time is thus set by an overall observation, care must be taken to observe a good workman and to note that he is not loitering on the job, and that he is using a correct method. Observations of a slow man, or of one who purposely loiters, are almost sure to give too long a standard time and to give trouble later, especially if they are made the basis of Efficiency Reward.

197. It therefore becomes very important to recognize loitering. This can be done because *no one can loiter uniformly.* Therefore if a worker's time for any repetitive operation, whether that be a single motion or a complete cycle of operations, approximates uniformity, it is a good indication that he is working faithfully and that the speed shown is the best of which he is then capable.

198. Of course unit times will never run absolutely uniform, and one therefore needs to know how to set a standard time from readings that vary somewhat, but not sufficiently to invalidate the study. My own practice is as follows:—

If the times vary almost enough to make me throw out the study, or if for other reasons I suspect loitering, I take the shortest time of which I have valid record.

If the times vary, but not quite so much as in the preceding case, I take a time near the best, usually the second best, but sometimes the third best or an average of several readings near the best.

If the times run fairly near uniformity, except some which are noticed as slow at the time of performance, I throw out the slow ones and average the rest.

If the times run pretty close to uniformity, I average them all.

If the times vary widely, but evidently because of variations in minor conditions which it would not pay to adapt, I average all the times.

The smaller the elements into which an operation is analyzed for the purpose of time study, the easier it is to see if any element is performed below normal speed; and in the original record made on the spot, these readings should be noted as "Slow." This memorandum is very valuable when it comes to working up the standard time.

My experience with my own method has been that if it errs, it will make the standard time too short. While it is desirable to get the time right as quickly as possible, the safe error on putting the time into the shop as a basis of Efficiency Reward, is to make it too short. It can always be lengthened, until it is found to be right, but once it is announced to the workers, it is very objectionable to shorten it.

Knoeppel states his practice in the matter as follows:

> 1. Where there are no pronounced variations in the readings, a fair standard may be determined by adding one-half the difference between best and average times to the best time.
> 2. Where there are pronounced variations in the readings, drop readings above the average; and using the balance, add one-half the difference between best and average times to the best time.

One's judgment in these matters is materially influenced by the importance and frequency of the operation, and consequently the amount of money that it will pay to spend on improving it. As Gantt says:

Having determined the minimum time in which the work can be done, the problem of setting a reasonable task (standard time) is still to be solved. If the work is simple, and is to be repeated many times per day, and day after day, the task should be a difficult one for even the good workers at first, for with repetition they will acquire skill, and in a short time it will become easy. In such work it will often pay to spend quite a long time to train workers to do it efficiently. If, on the other hand, the operation is but seldom done, it may not pay to spend much time training workmen to do it with great efficiency. In this case we should not make the task too severe, but such as a good workman can do without the preparation of special training.

199. In Table 11, Article 195, Main Cycle, Operations 9, 10, 11, it is noted that care is necessary in order to economize material. Any circumstance of this kind should be noted, and the standard should allow the full time actually taken for such operations, unless there is good reason to the contrary.

200. No standard time is allowed for Overall Operations 8, 9, 10, 11, 12 and 13 because the tool room ought to keep the dies in such condition that a machine operator would never be bothered in this way. Cutting out the time is no reflection on him. When this study was made, tool-room service had not yet been perfected to the point where it could be relied upon to this extent. This is an example of the fact that, in order to set a correct and permanent standard, the time-study man often has to look ahead to the effect of betterments that have not yet been made.

Some conditions, like the installation of an improved machine, or the development by the management of an improved method and the instruction of the workers in it, so evidently shorten the times necessary that a revision of standards is obviously fair, and the workers make no objection to it; but an improvement in

tool-room service would not be likely to appeal to a machine operator as justifying a cut in standard time. However, if it is likely to be a long time before a condition of this kind can be adapted and it is desirable to give the worker an efficiency reward soon, a temporary standard may be put in, allowing the worker the time required by the unadapted condition, with the distinct announcement that the standard is temporary and will be revised later.

201. Table 6, Article 166, gives a time study made for the purpose of determining a correct method and division of labor and standard time based thereon.

202. The time study of Table 12 was made for the purpose of seeing what principles of efficiency were violated and to determine quantitatively the loss of time due to each. Almost any time study will throw light on these questions; but it may be necessary, especially during preliminary work, to make some studies particularly to investigate them.

For a time study to determine standards it is necessary that an efficient workman should be selected; but when the purpose is to determine causes of inefficiency, workers of all grades of efficiency should be sampled. The sample given in Table 12 happens to be taken from a low grade.

At the end of Table 12 the losses of time shown in the study are classified according to the principles of efficiency, and the amount and percentage of loss due to the violation of each principle are summed up. In this case the largest loss of time, 34.5 per cent, might be prevented either by the application of the principle of Personnel, by substituting a skilled worker for the unskilled one found on this job, or by developing the skill of the actual worker by giving him instruction.

A few studies of this kind, in addition to the information of the same kind derived from other studies as a by-product, and from the analysis of the troubles of the minor executives, will do much to show what principles of efficiency are being violated, consequently what ones need to be applied to bring up the efficiency, and the relative importance of the several principles in the case in hand.

TABLE 12

Order—357 313 Date: ....
Articles No. 24 and No. 6202.
Operation—Sanding
Workmen— { Operator—No. 244, U—— B——
Helper —No. 248, F—— E—— }

Operator is a young fellow who has been employed only two months, and is not considered a good hand on this machine
Payment is on time rates only
Machine—Sander No. 09
Feed—Middle and fast. See Remarks column

Material— { For No. 24, quartered oak
For No. 6202, birch }

Part— { No. 24 —Solid beds, 32." × 50." × 7/8"
No. 6202—Solid tops, 72." × 22." × 15/16" }

Operation	Time (Minutes) Actual	St'd	Remarks
1. Under instruction by foreman....................	.86	.86	
2. Men hunting for something which they apparently did not find..................	3.06	.00	Adapt conditions
3. Millwright cut off end of sand paper..............	.12	.12	
4. Measure 4 birch pieces. (See operation 8)........	.6	.6	
5. Start machine...........	.42	.42	
6. Watch running of machine and stop same...........	1.38	.5	Correct slowness by rewarding efficiency
Carried forward	6.44	2.50	

TABLE 12— (CONTINUED)

Brought forward	6.44	2.50	
7. Restart machine.........	.26	.26	
8. Test machine by running through four birch pieces 5 in. × 12 in. × ¾ in....	.83	.83	
9. Inspect machine	.14	.14	
10. Try to get two of above small birch pieces out of machine...............	1.68	0.00	These little pieces should not have been put into the machine. Instruct or change personnel
11. Foreman got these out....	.08	.00	
12. Restarting .... 13. Helper trucking No. 24 beds to front of machine..	.8	.8	
14. Dust off beds............	.21	.21	
15. Helper moves truck to rear of machine..............	.34	.34	
16. Helper blocks this truck in position................	.21	.21	
17. Operator enters first piece in machine.............	.27	.18	Correct slowness by rewarding efficiency
18. Piece (17) stuck in machine	.27	.00	Instruct or change personnel
19. Pass one bed (17 and 18) through machine and place it on rear truck..........	.51	.39	Was on middle feed, should have been on fast
20. Inspect bed (17 to 19)....	.2	.2	
21. Operator enters first piece in machine	.23	.18	Correct slowness by rewarding efficiency
22. Pass 15 No. 24 beds through machine................. 23. Handle and inspect last bed out of machine onto truck..................	6.71	3.05 / .19	Feeding lengthwise on middle feed. Should have been on fast feed. Instruct or change personnel
24. Truck beds (13 to 23) to front of bed.............	.61	.37	Correct slowness by rewarding efficiency
25. Helper brings truck to rear of machine and blocks same in position..............	.21	.21	
26. Operator enters first bed in machine for second pass...	.18	.18	
27. Pass sixteen No. 24 beds through machine second time.................... 28. Handle and inspect last piece out of machine onto truck..................	5.05	3.64 / .19	Feeding lengthwise on middle feed. Should have been on fast. Instruct or change personnel
29. Truck beds (26–28) to front of machine.........	.37	.37	
Carried forward	25.60	14.44	

TABLE 12 (CONTINUED)

Brought forward	25.60	14.44	
30. Inspect work.	.53	.53	
31. Adjust machine.	.13	.13	
32. Operator enters first bed in machine for third pass. .	.11	.18	
33. Pass sixteen No. 24 beds through machine for third time.	5.41	3.64	Same as on (26)
34. Handle and inspect last piece out of machine onto truck.	.19	.19	Noticeably slow
			Cut out operations 35 to 43 by instruction or change of personnel
35. Truck beds (32–34) to front of machine.	.68	.00	Two cuts over face and one cut over back were enough for these beds
36. Adjust machine.	.15	.00	
37. Operator enters first bed in machine for fourth pass. .	.13	.00	
38. Pass sixteen No. 24 beds through machine fourth time.	5.35	.00	
39. Handle and inspect last piece out of machine onto truck.	.23	.00	
40. Truck nine No. 24 beds (37–39) to front of machine.	.37	.00	
41. Adjust machine.	.12	.00	
42. Operator enters first bed in machine for fifth pass. . . .	.2	.00	
43. Pass nine No. 24 beds (38) through machine fifth time; 44. Handle and inspect last piece out of machine onto truck.	4.31	.00	
45. Superintendent talking to operator.	.09	.09	
46. Truck two No. 24 beds (42–44) to front of machine	.56	.00	Cut out operations 45 to 50 by instruction or change of personnel
47. Adjust machine.	.13	..00	
48. Operator enters first bed in machine for sixth pass. . . .	.22	.00	
49. Pass two No. 24 beds through machine for sixth time.	.7	.00	
50. Handle and inspect last piece out of machine onto truck.	.28	.00	
51. Handle one piece.	.13	.00	
Carried forward	45.62	19.20	

TABLE 12 (CONTINUED)

Brought forward	45.62	19.20	
52. Putting through seventeenth No. 24 bed, discovered by foreman, four passes	3.65	.68	Should have had only three passes, along with the other 16 beds. Instruct or change personnel
53. Truck away seventeen No. 24 beds to elevator	.43	.43	
54. Truck No. 6202 tops to machine	.15	.15	
55. Helper brings empty truck to back of machine and blocks it in position	.1	.1	
56. Start one No. 6202 top in machine	.18	.18	
57. No. 6202 top (56) stuck in machine	.33	.00	Instruct or change personnel
58. Pass one No. 6202 top through machine for first time	.43	30	Correct slowness by rewarding efficiency
59. Handle same (58) onto truck and inspect	.36	.19	Correct slowness by rewarding efficiency
60. Start one No. 6202 top in machine	.15	.18	
61. Pass nine No. 6202 tops through machine	3.58	2.64	Only one can be in machine at once. Correct slowness by rewarding efficiency
62. Handle and inspect last one onto truck	.09	.19	
63. Truck ten No. 6202 tops to front of machine	.32	.37	
64. Helper brings empty truck to back of machine and blocks it in position	.07	.07	Noticeably slow. Correct by rewarding efficiency
65. Adjust machine	.19	.13	
66. Start one No. 6202 top in machine	.33	.18	
67. Pass 10 No. 6202 tops through machine	4.16	3.04	
68. Handle and inspect last from machine onto truck	.08	.19	
69. Bring truck to back of machine	.26	.26	
70. Get block for truck	.11	.11	
71. Block truck (69) in position	.06	.06	
72. Inspect No. 6202 tops	.20	.20	
73. Sort No. 6202 tops	.31	.31	
74. Truck No. 6202 tops requiring a second pass to front of machine	.75	.37	Noticeably slow. Correct by rewarding efficiency
Carried forward	61.91	29.53	

TABLE 12 (CONCLUDED)

Brought forward	61.91	29.53	
75. Operator at toilet. Helper oiling machine...........	4.75	4.75	
76. Supt. and foreman inspecting work................	.92	.92	
77. Start one No. 6202 top in machine................	.33	.18	Correct slowness by rewarding efficiency
78. Pass ten No. 6202 tops through machine for second time................	4.85	3.04	Fast feed was used. Operator failed to feed continuously. Correct slowness by rewarding efficiency
79. Handle and inspect last piece from machine on to truck....................	.09	.19	Induce operator to cut out, by rewarding efficiency
80. Handle pieces...........	.23	.00	
81. Truck No. 6202 tops to elevator................	.52	.52	
82. Under instruction by foreman....................	.26	.26	
Total { Stop watch....	73.86	39.39	
Total { Standard watch	71.94		

Efficiency = 53.5 per cent.

Losses of time shown by the above study are due to the following causes:—

Lack of—

Selected personnel, or of

Instruction—25.47 minutes; 34.5 per cent.

Adapted conditions, 3.06 minutes; 4.2 per cent.

Efficiency reward, 6.3 minutes; 8.5 per cent.

The total standard time plus the losses totals very slightly more than the actual time, because in a few cases the elemental standard allowed the men a little more time than they used.

In the observation of a large number of short times, as in Table 12, there is considerable chance of error. Readings of time by the stop watch will be more or less incorrect, and there is a chance that some readings may be lost. To make sure that such errors do not

escape detection, it is a good plan to take the total time independently by a standard watch. This was done, and the two totals are compared near the end of Table 12. It is not to be expected that the two totals will agree exactly; but they ought to come close enough to show that the stop watch readings are near enough for practical purposes.

203. As another example of the use of the time study to detect causes of inefficiency; in a shoe factory it was observed that the cutters of upper leather were losing a great deal of time. A study of the type shown in Table 12 showed that the losses of time were caused almost altogether by their inability to obtain the dies necessary to cut their work on the clicking machines. It showed also that in a very large percentage of these cases, it was a die of one particular pattern that could not be obtained. This brought to light the fact that the supply of those dies was insufficient for the demand, as the pattern was the best seller that season. However, it proved possible so to distribute the orders for this pattern among the cutters that, instead of every cutter having to use every die, as had previously been the case (so that a cutter who wanted a die was likely to hunt all over the room for it), the dies used by one cutter would be used by him only, so that he could keep them at hand, and make the supply of dies sufficient for the need.

204. In some work elemental operations do not repeat themselves in a definite cycle. For example, the work of making a complicated sand mold by hand could not be analyzed into cycles like those of Table 8 (Article 189) and Table 10 (Article 191). Where there is no definite main cycle, a finer analysis than that of Table 12 is usually impracticable with the stop

watch; and the observer must decide as to the efficiency of elements similar to those shown in that table, and set standard time accordingly.

205. It is a bad plan to try to make time studies without the knowledge of the workmen observed. It is impossible to observe closely enough to set standard time anywhere near right, or to make any kind of an analytical study, without the worker knowing that he is being watched. It is not exactly agreeable to any one to be closely watched, and to have every movement timed and recorded; but considerable of the unpleasantness is taken off by a frank explanation of what is desired. Where such an explanation is made beforehand, it is very unusual for a worker to object to a time study, even in the beginning of the work, although its purposes are then probably mysterious and therefore suspicious to him. If the Fair Deal and Efficiency Reward are consistently applied, the workers find out (and the sooner the better) that the work is beneficial to them, and their suspicions completely disappear.

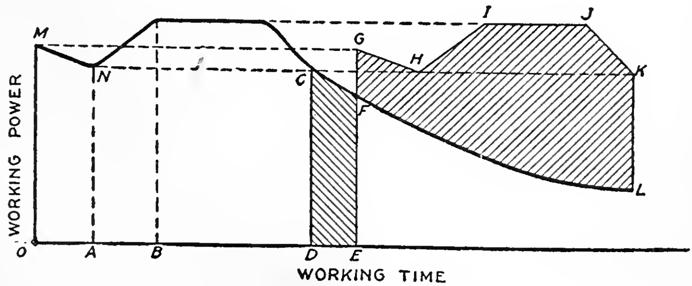


FIG. 5. FATIGUE DIAGRAM

206. Tests of the effect of duration of work on both muscular and intellectual power give graphic records of the general form of the heavy line curve in Figure 5.

It will be noted that power does not reach its maximum at once. A similar effect can be noted in time studies. If a number of successive elemental operations are timed at the beginning of a job, it will usually be found that the time per unit decreases somewhat irregularly until it steadies about a minimum. Therefore a time study commencing when a job is begun, ought to continue until time per unit ceases to show a progressive decrease. Variation of time per unit according to this law would, of course, not be an indication of loitering.

207. An essential feature of setting a correct and therefore permanent standard is the determination of a Correct Method. The time study is the usual means of doing this. See Table 6, Article 166. This is discussed further in Article 227.

208. The standard time for an operation must cover not only the main cycle but also auxiliary operations, such short interruptions as can not be avoided, and rest. When a study of overall operation is made, the final standard can be derived directly from it; but in order to advance the time-study work rapidly, most studies should cover the main cycle only.

My own practice is, after having determined the time for the main cycle, to add to it 20 per cent for auxiliary operations and minor interruptions, and then to add an allowance for rest.

209. Experimental research as to required rest is needed, but the following may be used as a rough guide. Workers who are used mostly to watch machines in operation, and who are seated and otherwise comfortable while doing so, need no allowance for rest. Examples of this occur among machinists operating heavy machine tools, and among women weaving wire

cloth. On most kinds of work, 10 per cent of working hours for rest should be allowed for males and 12 per cent for females. Rest should be increased beyond this, according as the worker is exposed to high temperatures, is subjected to anxiety or other nervous or mental strain in connection with his work, or has to do heavy muscular work. Thirty per cent of working hours for rest may be considered an ordinary maximum, but is not the limit; and 100 per cent of rest may be approximated in some extreme cases, as in some athletic performances of great severity and very brief duration, which a good trainer will allow to be done only once per day. For example, suppose that in Table 11 (Article 195), only the main cycle had been covered, and that the standard time for it had been set at .849 minute per strip. The standard to cut one hundred strainers would then be calculated as follows:—

Main cycle per strip	.849	minutes
Auxiliaries and interruptions, 20 per cent of main cycle	.17	"
	1.019	"
Divide by .9 to allow 10 per cent of total time for rest	.113	"
Total time per strip	1.13	"

Average number of strainers per strip = 21.7

$$\text{Total time for 100 strainers} = \frac{1.13 \times 100}{21.7} = 5.21 \quad ''$$

In comparison with this ......'s time for 100 strainers was .1 hour, or 6 minutes.

If this, or a similar method is used, it is a good plan whenever a study covering both main cycles and aux-

iliary operations is made, to compare the standard time given by it with what would be given by the allowances, as a test of the latter, especially to be sure that they do not allow too much time.

It will probably be obvious in the case of some operations that the standard allowances are not sufficient, and for them total standard time should be determined by overall studies.

My experience is that the allowances above given, if they err, give too little time, so that standards determined by them can be relied upon as safe to put into the shop. Results should then be watched, additional studies should be made, if necessary, and standards which are found to be too severe should be promptly eased off.

209. One cannot safely err without limit in making standards too severe as a first trial, because it makes the workers very resentful to put them up against unreasonable standards. It is a delicate and skillful operation to get the first approximation near enough to the final standard without spending too much time on the preparatory studies.

210. The advisability of allowing direct workers to perform auxiliary operations for themselves is discussed in Article 216. Assuming for the present that they must be allowed, at least until a better method can be introduced, to set up machines for themselves, the question arises as to whether a separate standard time should be determined for the set-ups, or whether the time for set-up and for operation should be stated as one.

Either method has advantages and disadvantages, and that one should be chosen which is better for the particular case. There is no reason why one method

should not be used for some operations and the other for the rest, in the same plant and even in the same department.

The advantage of a separate standard time for the set-ups is accuracy and, consequently, a fuller application of the Fair Deal. If the set-up is very long and complicated, and especially if it varies much with the nature of the work, a separate standard may be required.

For example, a certain machine was used to cut pieces to length. On analysis by time studies, it was found that a complete set-up consisted of three elements as follows:—

ELEMENT	STANDARD TIME
Original set-up	.2 hour
Change of length to which pieces were cut......	.1 "
Change of cutting tools, to suit material cut....	.2 "

An order of 1000 pieces to this machine might require all kinds of time to set-up, according to the number of different materials contained in it, and the number of different lengths to which they were cut, so that it was necessary to set standard time accordingly.

Now suppose that the planning department might have assembled an order of 1000 pieces all of one length and material. The time for the set-up would then be .2 hour. Now suppose that the planning department neglected this opportunity and sent to the machine 1000 pieces of three different lengths and of such materials that two changes of cutting tools from the original set-up would be required. The standard time for the job under these unfavorable conditions would then be:—

ELEMENT			STANDARD TIME	
Original set-up			.2	hour
Changes from above	Length	$.1 \times 2 =$	.2	"
	Cutting tools	$.2 \times 2 =$	.4	"
Total			.8	"
Time to set up a correct order			.2	"
Loss of time by fault of planning department			.6	"

Now in the service cards and in any graphic record like Figure 3 (Article 131) this error will not show up because the loss of time is in the standard itself, consequently the unnecessary .6 hour will be spent in setting up, and still the records will show 100 per cent efficiency.

The disadvantage of the separate standard is that it covers up any failure of the planning department to do its own work so as to minimize the amount of time for setting up. One advantage of the single standard for set-up and operation combined is that, if it is set right for a standard order, any failure of the planning department to assemble such an order shows up at once in a lowering of efficiency. Moreover the service cards will show exactly where the inefficiency occurred, and why.

Obviously if the work is sufficiently repetitive, so that a standard order can usually be approximated, the combined standard has the balance of advantage.

211. The Fair Deal requires that the combined standard should be set, not for the most efficient order that can ever be assembled, but for the average order that is practicable in regular operation. Every variation from the standard order then introduces an element of chance into the efficiency of the worker, according to which he profits or loses, not according to

his own efficiency, but by circumstances beyond his control. This element of luck can not be entirely eliminated, and has appeared already in the allowance for minor interruptions.

Nevertheless, this element is objectionable, and it should be reduced as much as is commercially profitable. My experience has been that when luck runs against the direct workers, they are very apt to suspect unfairness, and that they immediately forget the times when it is in their favor. If the work varies much, this fact causes any elements of chance to increase the difficulty of dealing with the workers. This brings us around again to the point that, with variable work, accuracy and the Fair Deal require a separate standard for setting up.

The extent to which variable or unadapted conditions are unfair to the workers, depends largely upon the form of their Efficiency Reward, and comes up in the chapter on that principle, in Article 290.

The element of chance is reducible by the use of recording instruments which show exactly the conditions that have been encountered. For example, I once had a great deal of trouble with a gang operating a Linderman machine in a furniture factory. This machine builds up wooden parts like the writing beds of the sketch, Article 213. The necessary time depends upon the length of the parts A, B, C, D, E, and the cleats, and upon the number of these parts. The number of parts A to E would vary inversely as their average width; and this would vary because the stock sawyers had to produce such widths as would allow them to cut the lumber economically. The length of the pieces and the built up width were necessarily stated to the gang in the service card, as they could

not otherwise have known what to do. The average width of pieces A to E was determined by records of about sixty thousand of them, and the effort was made to determine their number by the following equation:

$$N = \frac{nW}{w}, \text{ in which}$$

N = number of pieces A to E,
n = number of built up parts (Given by the service cards)
W = width of built up parts, and
w = average width of 60 000 pieces A to E.

This went all right until one day the gang got a run of narrow pieces. Their apparent efficiency went away down and they became convinced that the standard time had been reduced, and that the whole thing was a scheme to exploit them.

This trouble was finally removed by installing a counter which was operated by the pieces as they passed through the machine. It was put where the gang could see it and read it. With some difficulty they were convinced of its accuracy. They were also allowed to read it and report the figures to the despatcher, instead of his reading it, for the service card records. This treatment in time convinced them that they would receive a Fair Deal and after that they got after their Efficiency Reward, and gave the owners 43 per cent increase of production for a 20 per cent bonus on their previous time rates.

However it is better to determine a standard from a general average, than to have no standard at all. Harrington Emerson tells of a workman who turned off locomotive tires. These tires would have hard spots in them and, when the man struck these, he had to slow down his lathe. No means were found to adapt

this condition, but standard time was averaged from determinations of a large number of tires. The result was that the workman's average efficiency for successive pay roll periods was almost constant.

212. Another advantage of the single combined standard time for set-up and operation is simplicity, because it states the time simply as so many hundredths of an hour for so many pieces. This consideration will be negligible, unless it materially reduces the amount of clerical labor needed to plan and despatch. Standard times which take account of all the facts can be expressed in the form of algebraic formulas and I have had no difficulty in teaching boys of only grammar school education to use such formulas correctly; or it may be found easier to express the formulas as curves and to teach the clerks to use the latter.

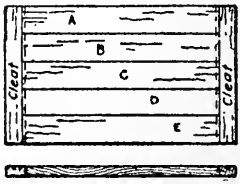
213. When similar parts vary in dimensions only, a long series of standard times can be easily determined. An example of this is shown in Table 13. The operation consisted in cutting off surplus material along all four edges of the writing beds, shown in Figure 5, so as to reduce them to the sizes shown in the column headed, "Dimensions." In preceding operations rough dimensions had been so adapted that only one cut along every edge was needed. Standard times of 2.53 hours per hundred 42 by 32 by 1¼ inch beds, with oak or chestnut cleats, and 2.9 hours per hundred with birch cleats, were determined by time study. X—— Y——, a very good and reliable workman, was given a lot of these beds with oak or chestnut cleats, and some 60 by 32 by 1¼ inch with oak or chestnut and some with birch cleats, and was told to go ahead and keep his own time and report it, and was

also told that it was proposed to use his time to set standards for the line, except the 42 by 32 by 1¼ inch bed, on which he was informed of the standard already set by time study.

He reported that this standard time was all right, and also reported the times shown in Table 13 for the 60-inch beds. For reasons which it is unnecessary to explain, it was expected that the standard time for beds of the same materials ought to vary with the sum of their lengths and widths. As the times reported by X—— Y—— for beds with oak or chestnut cleats were almost in this proportion, the time for the other beds with these cleats was interpolated and exterpolated according to these dimensions.

TABLE 13

Date—
Workman—See Columns, Remarks
Helper—One per workman
Operation—Shaping to size
Machine—Shaper 72
Material—See Columns
Part—Writing beds



Dimensions	Material of Cleats	Standard Time in Hours per 100 Beds	Remarks
42. × 32. × 1¼	Oak or chestnut	2.53	X— Y— reports that he can do these beds at this rate. Agrees with standard set by time study
	Birch.........	2.9	
42. × 36. × 1¼	Oak or chestnut	2.71	
	Birch.........	3.14	
50. × 32. × 1¼	Oak or chestnut	2.89	
	Birch.........	3.37	
50. × 36. × 1¼	Oak or chestnut	3.07	
	Birch.........	3.63	
54. × 32. × 1¼	Oak or chestnut	3.07	
	Birch.........	3.63	

TABLE 13 (CONCLUDED)

54. × 36. × 1¼	Oak or chestnut	3.25	Q— T— did sixteen of these oak beds at the rate of 3.82 hours per 100. Efficiency, 85 per cent.
	Birch.........	3.88	
60. × 32. × 1¼	Oak or chestnut	3.33	X— Y— reports that he can do these beds at the rates called for by these standards
	Birch.........	4.00	
60. × 36. × 1¼	Oak or chestnut	3.51	Q— T— did seven of these birch beds at the rate of 3.85 hrs. per 100 $\frac{4.26}{3.85}$ = 111 per cent. efficiency
	Birch.........	4.26	
66. × 36. × 1¼	Oak or chestnut	3.77	
	Birch.........	4.61	
72. × 36. × 1¼	Oak or chestnut	4.05	
	Birch.........	4.98	

CHECK

On these dates ——, ——, X—— Y—— did the following job:

NO. OF BEDS	DIMENSIONS	MATERIAL OF CLEATS	STANDARD TIME HOURS	ACTUAL TIME HOURS	EFFICIENCY PER CENT
26....	50×32×1¼	Oak..........	.75	..	...
12....	50×32×1¼	Birch	.41	..	...
43....	60×32×1¼	Birch	1.72	..	...
49....	54×32×1¼	Birch	1.78	..	...
26....	42×32×1¼	Oak..........	.66	..	...
7....	42×32×1¼	Birch	.2	..	...
			5.52	5.3	104.

Average of previous records of X—— Y——'s efficiency, 105 per cent.

As the time thus confirmed for the smallest beds with oak or chestnut cleats seemed fairly consistent with that determined by time study only for the same beds with birch cleats, the latter was accepted, and times for the rest of the line with birch cleats were determined by interpolation and exterpolation according to dimensions. The results were checked by comparison with the times for beds with the softer cleats.

The table was then checked as shown, by two existing records of Q—— T——, a good but irregular workman. As a variation of his efficiency from 85 per cent to 111 per cent was only what would have been expected from his general record, these comparisons were considered as confirming the table.

The standard times were also checked by giving X—— Y—— the mixed order shown at the end of the table, on which the results were so consistent, that the times were then established as the basis of Efficiency Reward.

214. Table 13 illustrates four important points:—

1. The necessity for taking all short cuts consistent with substantial accuracy, in the determination of standards, in order to cut down the cost of this work.
2. The possibility of determining standard times in series, with a minimum expenditure of time and labor.
3. That, as records of standards analytically determined, become available as bases, records of regular shop performance may determine other standards by comparison.
4. That *all* standards, not merely those of time, should be checked, if possible, by methods independent of their determination.

215. The determination of standard times is facilitated if the other parts of the schedules, Table 3, of the department can be made out first. As soon as this information is available, it can be seen what operations are frequent enough to justify making minute time-motion studies in order to determine a large number of standards by formulas like those deduced in Tables 8 (Article 189) and 10 (Article 191), what standard times can be quickly determined by a series

like that of Table 13, and what operations had best be sized up quickly by overall timing of a few main cycles.

216. Referring to Figure 5 (page 229), Fatigue Diagram, universal experience shows that, by stopping work at some point *D* and resting at some point *E*, the power can be brought up from that of fatigued performance, *EF* to a power *EG* equal to *OM*, that of initial performance, and that thereby an area *FGHIJKL* can be added to the diagram, greater than the area *CDEF* lost during rest.

If any one doubts this, let him try to work continuously with absolutely no rest.

It is evident that in order to attain a maximum of continuous power, rest should begin when fatigued performance, *DC*, equals *AN* and should continue until renewed performance, *EG*, will equal initial performance, *OM*; *provided* that area *CDEF* is less than area *FGHIJKL*. (A voluminous discussion of fatigue will be found in Goldmark's "Fatigue and Efficiency.")

The obstacle to the practical application of this is that both the form and the length of the Fatigue Diagram differ greatly with individuals. It would be easy enough to determine, by time studies, when and how long any individual should rest, but the result could not with certainty be applied to any one else.

Any investigation of this kind evidently belongs to the ultimate refinements of betterments.

The salient facts of immediate commercial interest are:—

That the output of workers is increased by suitable short intervals of rest during working hours;

That by setting standard times, including allowances for reasonable rest, giving the workers an efficiency reward, and allowing them to rest at their own discre-

tion (except as this is modified by work in gangs) very great gains in efficiency with corresponding reductions of labor cost can be effected as compared to previous practice.

Also rest does not mean a complete cessation of activity. The effects of fatigue, though somewhat general because of the distribution of the fatigue poisons by the blood, are most intense in the organ which has been at work. This is a matter of common experience. Hence local rest is needed long before general rest. Also much work, especially that of machine operators, is almost incredibly monotonous. Monotony hastens fatigue, hence a certain diversity of work increases efficiency and output by affording local rest and relieving monotony.

For example, in adapting conditions in a punch press department, it was decided to allow the press hands to open boxes of sheet tin, and so forth, for themselves, instead of having this done for them by laborers, with the deliberate purpose of affording the press men local rest and variety of occupation. These requirements conflict with those of division of labor and specialization, and one cannot go too far in either direction, without loss of efficiency. The time study is the usual means for determining the efficient compromise.

217. The question of hours of labor is somewhat similar to that of rest. It ought to be possible, after conditions have been sufficiently adapted so that they can, in the main, be kept approximately constant, to conduct a series of experiments in which only the hours of labor would be varied, and thereby to determine the number which gives the greatest output per unit of cost.

218. When any job is seldom repeated, as in a department which does special work or in a jobbing shop, it is sometimes possible to analyze the work into recurring elements. In that case standard times can be determined for the elements, and the standard for any job can be built up out of the elemental standards.

219. When this is not possible, the foreman's guess is better than no standard. If a time study would establish a standard of three hours, it is better to have a worker, under the stimulus of Efficiency Reward, attain a standard of four hours set by the foreman's guess, than to have him take five hours without a standard. If Records are kept they will soon show whether the foreman has a tendency to estimate either too little time or too much, and he can take this into account in setting times thereafter. In this case too long a standard time once set does not create an embarrassing precedent, as it does in the case of repetitive work.

220. There are two classes of standards of materials, specifications, and standards of waste in use.

Specifications are discussed in Articles 24, 174, 176. About all that it is desirable to add to what is said there is to call attention to the value, in the preparation of specifications, of competent counsel through staff organization. For any buyer, except Government, the name of a proprietary article may be a sufficient, and the most efficient, specification.

221. Standards of waste of materials in use are discussed in Article 331. Such standards are much more feasible than is usually supposed. There is hardly any common industrial use of material for which the setting of these standards is more difficult than for the cutting of tanned hides into pieces for shoe uppers.

Not only is every hide different from every other hide, but the problem of fitting the odd shapes of the shoe parts into the hide, is never twice the same.

Nevertheless the value of the material has caused shoe manufacturers to set standards.

The process is to establish grades of shoes and of leather, commonly known as A, B, C and D. An order for a lot of shoes goes first to the leather store room. There a skilled workman sorts out the necessary material for the order in the proper proportions of A, B, C and D. Notwithstanding the difference in hides, an expert sorter will pick out any number of lots of hides for several hundred pairs of any grade, so that any one of the lots will cut to the order with practically the same waste as any other lot.

The work of the sorter adapts the conditions to a close enough approximation, so that it is practicable to set standards, which are commonly expressed as so many square feet of uncut hide per pair of shoes of any size, width, pattern and grade. The sorter calculates from the standards the number of square feet of hide needed for the order, and issues this amount to the shoe cutter.

Standards of waste of material in use are commonly set either by averaging all previous records, by averaging previous records of exceptionally good performance only, or by giving a sample job to an especially expert and economical workman and deriving the standard from his result. Any of these methods is preferable to having no standard; but one can not be sure of a correct standard, unless the determination includes the analytical study of waste in at least one sample case. In order to be sure that the error of sampling is not great, it is a good plan to compare

the result of the analytical study with such records as are available. The analytical study may reveal ways in which material can be saved, just as a time study often shows how to save time. Hence one would expect a standard for materials, set by analytical study, to allow less waste than one set by comparative records.

The bills of materials mentioned in Article 113 should contain statements of the standards of waste in use, as soon as the latter have been determined. These, of course, may be expressed as so much material allowed for so much work.

Just as with standard times, a standard for waste of materials on repetitive work should not be made more severe after it has once been set. Therefore, in case of doubt, the standard should be made severe enough at first; and if, in use, it appears to be too severe, it should be re-studied, and should be promptly eased off if that course is found to be correct. Standards for materials do not affect the workers quite so closely as do standards of time; but still first approximations to standards of waste cannot be made excessively severe without causing the ill will of the workers.

Here again skillful work is required to get the first approximation close enough without spending too much time and money on its determination.

222. In determining standards either of time or of waste of materials, it is to be expected that under the pressure to get them out quickly and at a minimum of expense, a few will be made too easy, and that the workers will earn very large Efficiency Rewards on them. These should be allowed. The demonstration of the Fair Deal thus made will pay a profit in the long run.

223. In connection with the determination of standards, especially those of indirect expense, attention is called to the value of competent counsel through correct Organization. For example, a power engineer, given a description of the power plant, could at once set all its standards of any importance from his general knowledge. Any one not so qualified would need a lifetime of research to determine them.

224. Referring to Articles 342 to 344, when burdens and standards have been determined for every operation, we can substitute in the cost formula

$$M\,(U + u) + H\,(W + w) + h\,(E + e),$$

for M, standard quantity of direct materials,
for U, standard unit price of direct materials,
for u, burden on direct materials,
for H, standard man-hours of direct labor,
for W, standard wages per man-hour,
for w, burden on direct labor,
for h, standard hours of direct use of equipment,
for E, hourly cost of running direct equipment, and
for e, burden on direct equipment;

and obtain the standard cost of the operation.

The sum of the standard costs of all operations is the standard cost of the finished article.

If this is not low enough to meet competition, it is necessary to:—

Improve processes and equipment and reduce standard cost; or

Redistribute the overhead as explained in Article 339, so as to enable the article to meet competition; or

Combine the two above; or

Demonstrate to the competitor that he is selling at a loss, or

Cease to make the article.

An important value of the standard is that it gives a common measure to which all kinds of production can be reduced.

Take painting, for example; it looks simple and easy, but is an arduous occupation, calling for a great deal of skill and knowledge, and is dangerous to the workman. The interior of a ship had to be painted, three coats, different paints for the different coats and for different places in the ship. Some of the metal was smooth, some was rough; some areas clear, some full of rivet heads, air ports, fittings, etc.; some areas unobstructed, some so obstructed that the painter had to fasten his brush to the end of a stick in order to reach them, and finally, both the sides and overhead had to be painted throughout. Prior to the establishment of real standards I maintained graphical statistics of daily production, recording the daily yardage of each painter; and I went so far as to make a separate curve for each kind of paint and each coat. But there was absolutely no way of interpreting the figures. A low yardage might represent a big day's work, if the man had been doing overhead, obstructed work, say; and another man might turn in a yardage three times as great and yet not work nearly so hard. To judge each man's work from day to day, and to compare different men on the same day, were impossibilities, due to the variable elements affecting these figures.

When, however, by time study, a standard time for plain straightaway side work was worked out, and factors obtained for reducing all other kinds of painting to this common denominator, we had a standard of performance and a standard of cost for all men and all classes of work; after which the handling of that force became a simple matter of detail.[1]

225. An important point in connection with determination of commercial standards is not to be too fussy about it.

Accuracy must be paid for, and excessive accuracy is no more worth the cost than it is in machine design. If efficiency is perhaps only 70 per cent, it is usually

[1] F. G. Coburn, "How to Use Statistics in Management."

much more important to get into effect quickly a standard that is 5 per cent from the true value, than it is to haggle and delay and spend a lot of time and money to get any nearer right. There is valuable truth in the engineering maxim, "Good enough is best."

Chapter XI

CORRECT METHODS

INSTRUCTION

226.

J. R. SMITH says, "It was one of the intellectual shocks of my young manhood to discover that an analytical chemist could often get only $50 a month. I had long looked with awe upon the accurate percentages and detailed reports of the analytical chemist. This water contains 2.341 grains of such and such a substance per gallon. I wondered at the marvellous man who could get out such fine results, and to learn that at times he gets but $50 a month was a shock. The explanation is this. The chemical analysis of ordinary specimens is a technical process of a perfectly definite character. If a work is definite and therefore capable of being reduced to clear cut instructions, the pay that it commands is not likely to be high, even though the work itself be complicated. It requires good memory and painstaking obedience to instructions. Many persons have these qualities. The scarce attribute is judgment, that indefinable quality capable of meeting a new situation and handling it with common sense, or gumption, to put it in a homely term."

It is of interest in this connection that a man capable of earning only \$50 a month can be enabled to do chemical analysis. How to accomplish such a result is surely worth the attention of every employer of labor. Evidently it is done by the application of the efficiency principles of the Correct Method and Instruction. A research chemist has first determined the method and recorded it in permanent instructions, and by the aid of the latter, the actual analysis can be performed by a man of much less ability. The application of these principles results in a "transfer of skill" from the man of greater to the man of less ability. Auel says:

> An . . . important line of work consists in the development of manufacturing processes and formulæ which, when standardized, are recorded in permanent form and issued to the various manufacturing departments involved. In this way uniformity in product is assured, there is no needless repetition of lessons or experiences previously learned, and the company is made independent of any individual's knowledge.

227. In Table 6, Article 166, a Correct Method is determined by a time study. In Article 203 there is another example of the determination of a Correct Method by time study. In industry this is the usual means to that end. Extensive time-motion studies and even moving-picture studies are profitable for this purpose, if the amount of money spent in wages for any operation is considerable. For the determination of a Correct Method, comparative studies, especially moving-picture studies, of several good workers doing the same work independently, will give valuable information. In the case of the analytical chemist, time studies probably did not enter into the matter at all. The time study is a particular case of the universal

means to the Correct Method; that is, scientific investigation. Gantt says:

We can never be sure that we have devised the best and most efficient method of doing any piece of work until we have subjected our methods to the criticism of a complete scientific investigation. . . . In order to get the best results these four conditions are necessary:

First. Complete and exact knowledge of the best way of doing the work, proper appliances and materials. This is obtainable only as the result of a complete scientific investigation of the problem.

Second. An instructor competent and willing to teach the workman how to make use of this information.

Third. Wages for efficient work high enough to make a competent man feel that they are worth striving for.

Fourth. No increase of wages over day rate unless a certain degree of efficiency is maintained. . . .

An investigation divides itself into three parts as follows: An analysis of the operation into its elements; a study of these elements separately; a synthesis, or putting together the results of our study. This is recognized at once as simply the ordinary scientific method when it is desired to make any kind of an investigation, and it is well known that until this method was adopted, science made practically no progress.

228. In the investigation, analysis and synthesis, Gilbreth has pointed out that the best results can not be obtained merely by the elimination of inefficient elements. This may effect considerable improvement, but will not attain the possible limit unless the elements retained are improved wherever possible. This may take the form of substitution of new elements for the old until the whole operation is radically changed. A well known example of this is Gilbreth's improvement of brick laying. Evidently there is an opportunity here for the use of competent counsel through correct Organization.

229. The statement has often appeared that the time-study man who sets a standard ought to be able per-

sonally to do the work in the time he sets. The reading of these chapters ought to convince any one that time study itself is a highly skilled specialty. If beside requiring this skill, we insist upon the manual skill of a 100 per cent efficient workman, we either restrict the activities of every time-study man to a very few operations, or we call for a superlatively gifted creature who is rare indeed. In either case we greatly increase the cost of time studies; in the first, by multiplying the number of men; in the second, by using very high priced men.

Instead, this is a case for division of labor, as shown by Figure 1, Article 66, the Diagram of Organization, in which separate corps of time-study men and of instructors are provided.

230. The experience of efficiency engineers and of educators in trade schools and in Y. M. C. A. vocational classes, is that the best teachers of industrial processes are skilled workers who also possess some natural gift for teaching.

231. Such an instructor and a time-study man can very well co-operate. Gantt, in "Work, Wages and Profits," Chapter VIII, gives in detail the history of a case of such co-operation. Any one interested in the matter will do well to read it carefully. After doing so, he will understand better than is otherwise likely, what difficulties are encountered, how the time-study man and the instructor help each other and both help the direct worker, and why the first two can accomplish more together than either can separately. In Table 12, Article 202, an actual time study shows the possibility of saving 34.5 per cent of the time of two workers by the joint labors of a time-study man and an instructor.

The time-study man has first to study the work, determine the Correct Method, and establish standard time for the performance of the task.

Considerable of this may have to be done in order to obtain the data necessary for the selection of a worker as instructor; but betterment will be advanced if the latter can co-operate even while the preliminary work is going on. Especially in the determination of the Correct Method, this co-operation is valuable, the time-study man making minute analyses of the work and pointing out to the instructor where time is lost, and the latter suggesting improvements and trying out all changes in actual work before they are adopted.

232. As this work shows up unadapted conditions, the management should adapt them as fast as possible. It is supposed that meanwhile Planning and Despatching are also being installed.

233. As soon as these parallel lines of work have gone so far that it can be expected that direct workers will be able, without much delay, to earn an Efficiency Reward on the standards set, the work of the time-study man and the instructor should be extended to as many direct workers as they can handle at once. The instructor should teach these men the Correct Method, guide them in the application of it, and seek to develop in them a manual skill equal to his own.

The time-study man should analyze their work, find out where they lose time and from what causes. Whenever they lose from lack of skill or from failure to follow the Correct Method, he should call the attention of the instructor to them and the latter should give special attention to these matters. Whenever the direct workers lose from other causes, the time-study man should take the matter up with the management,

through the regular channels of Organization (See Figure 1), and the management should remove such causes of loss as fast as possible.

234. In summing up the instance cited in Article 231, Gantt says:

> In considering this work an important element to be considered is the time needed. When we began our study in June, 1908, we already had in operation means for learning how long each worker spent on every job and how much work was done.[1] There was also in existence a system of laying out the work from the office.[2] In other words the general mechanism of our system was in operation and working smoothly, yet it was several months before we got enough task work going to make any real show. If we had attempted to introduce it much faster, we should have met with two difficulties. First, it would have been impossible for us to remove all the obstacles for a large number of weavers.[3] Second, the poor weavers would probably have persuaded the good ones not to try to do as we wished. . . . Time is needed to overcome prejudice and to change habits. This is a psychological law, and its violation produces failure, just as surely as the violation of the laws of physics or chemistry.

235. A great deal of tact is necessary in introducing the form of Instruction thus far discussed. Unless the management has previously given the workers a Fair Deal for so long that they have acquired confidence, they are almost sure to think that the whole thing is a scheme to exploit them.

If, then, all the direct workers are put under instruction at once, there is danger of open rebellion, to say nothing of the difficulty of handling a large number of workers at the outset by an instructor who has probably never before taught anybody anything. If a few direct workers are selected for instruction, they will

[1] Records.
[2] Planning and Despatching.
[3] Adaptation of Conditions.

probably find it impossible long to withstand the sentiment of the shop, unless they are soon encouraged by a substantial increase in their earning power.

In order to avoid these difficulties, it is necessary before any direct workers are put under instruction, that the work should be carefully studied, the Correct Method and Standard Time determined, that Conditions should be Adapted, and Planning and Despatching developed to the point where good workers can begin to earn an Efficiency Reward after only a short time under instruction and without working excessively hard.

It is also necessary that the instructor should be paid enough to make him value the job, and that he should receive an Efficiency Reward based on the efficiency of his pupils.

The instructor should then be broken in gradually by giving him at first only one, or a very few, direct workers; and these should be carefully selected from among those who are not only quick and skillful, but are also willing to give the new methods a fair trial. If these men find at once that they are not driven to excessive exertion, and soon find that their earnings are increased, they will value the opportunity to work under the new methods, and others will want to join them.

The whole thing will be helped very much if the scheme has previously been explained to the workers. Methods for doing this are outlined in Articles 306 and 307. Even when all this has been done, the management may find some irreconcilables blocking the work by agitating against it, and must apply vigorous Discipline to these trouble makers, if it expects to succeed.

236. In many cases, as in Table 6, Article 166, the Correct Method is simple enough, so that all the workers need is a written statement of it, which may be in form similar to that shown for the Standardized Operation in Table 6. We then have a special case of the Correct Method, a Standardized Operation; and a special case of Instruction, a written Standard Practice Instruction. These written forms should be issued, with the service cards, to the workers concerned, at least until the methods become so familiar that instructions are no longer needed.

A variation of the Standard Practice Instruction consists of statistical or other information, usually for the use of foremen or other executives, of which an example is given in Table 14.

237. A company manufacturing typewriters employed an expert on twist drills to standardize their grinding and to make out standard practice instructions for it. One of the company's mechanics complained of the standard forms and claimed that he could grind the drills so that they would work faster; and when given an opportunity, he made good on his claim.

No matter how methods have been determined, or how much confidence is felt in them, all hands should always be encouraged to suggest further improvements, though some efficiency engineers require any direct worker using a standard method to make a good efficiency on it at least once, before they will entertain suggestions from him.

238. There are many operations for which the workers' methods can be accepted, either because they are good enough or because the operations are so seldom done that it would not pay to spend any money to

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improve them. In these cases the standard times should be determined as quickly and inexpensively as possible, the principle of Efficiency Reward should be applied and the workers usually need little or no instruction.

239. There are usually some operations which occur so seldom that they do not repay any more attention than is necessary to get them done, and on which the workers should be paid straight time rates only.

240. In connection with time-study work all jobs should be assigned to one of these four classes and be treated accordingly:

> Those which will repay the utmost improvement of the method and the continuous service of an instructor;
>
> Those which should be covered by written standard practice instructions;
>
> Those to which the principles of Standards and Efficiency Reward should be applied with little or no instruction;
>
> Those on which the workers should be put on time rates without any more attention than is necessary to get the jobs done.

241. The Standardized Operation for the sawyer in Table 6, shows an element "Handle and inspect board —.406 min." The standard time for this element is 65 per cent of the whole time of the main cycle. In this element the sawyer studies the board, sees what defects it contains, decides what defects he must cut out entirely and what he can leave either wholly or in part to be removed in later operations or to be covered by veneers or concealed inside the assembled article, and what ones and what numbers of the parts called

for by his order he must cut from the board so as to waste as little as possible.

A similar case occurs with men cutting the parts of uppers of shoes from tanned hides, whose problem is almost exactly the same, substituting hides for boards and shoes for furniture.

Evidently in these cases, standardization is impossible, and we must rely upon the intelligence of the direct worker on the job. To be intelligent he needs to know his material, the complete manufacturing process, and the demands upon the finished article in use.

There are many cases in which efficiency can be obtained only by the exercise, by the direct workers, of skilled judgment, based on wide knowledge.

242. It is this need of knowledge by direct workers which has produced the demand of employers for vocational education. Here again the Fair Deal requires that society, which as the consumer benefits by efficiency, should, as the government, bear its share of the burden.

243. On vocational education, Kimball says:

> No general solution of this problem has yet been arrived at and the entire matter is in a very chaotic state. The following are the most important methods which are, at present, being tried out in various parts of this country:
>
> (a) New forms of apprenticeship which include academic training and which usually cover a narrower range of practical work than the old systems, and do not require such a long period of apprenticeship.
>
> (b) Privately endowed or supported trade schools which aim to send out men quite completely prepared to enter the industries.
>
> (c) Vocational and trade schools, supported by the State or city and forming an integral part of the public school system.

(d) Part time schools in which the pupil receives his training in either a private or public school and obtains the practical part in an actual factory, mutual agreements being made between the school and the shop so that the student alternates between the two under the direction of instructors who see that co-ordination of theory and practice is effected.

. . . Fundamentally, however, there is only one kind of school whose doors are open to all comers and which is not, or at least should not be, dominated by any private interest, and that is the public school. In the writer's opinion the only general solution of the problem that can ever be reached must, therefore, be based upon that system.

244. Germany has worked much longer, harder and better than we have at this problem; and that is one reason for her high efficiency. In Germany even such minor trades as horse shoeing and chimney sweeping receive attention from the trade schools. The horse shoer is taught the anatomy of horses' hoofs by dissection. The chimney sweep is taught the chemistry of combustion and the physics of chimney draft.

245. The examples given of the sawyer, the shoe cutter, the horse shoer and the chimney sweep, show that their work is based upon a foundation of *theory* which they must know in order to be thoroughly skilled and efficient. There are many other workers who are in the same situation.

246. From experience in this country and in Germany certain facts are now clearly evident. These are:—

That schools alone almost always fail to turn out manually skilled and practical workmen;

That industrial plants can not teach the theory of their work nearly so well as the schools can do it;

That both theory and practice are best learned if

instruction in the two is given together, with care to point out the relation between them;

That these facts indicate the part time school, in combination with instruction in practice and manual skill in the industry itself, as the most efficient solution of the problem; and

That even the part time school is most successful when it is under governmental authority and attendance is compulsory.

247. The necessity for putting instruction in practice and in manual skill into the industrial plant and in theory into the schools, is apparent from the consideration of the question of equipment alone.

Fitchburg, Massachusetts, in this way teaches machine-work, pattern-making, saw-making, drafting, iron-molding, tin-fitting, piping, printing, textile and office work; in Munich forty-seven trades are taught; Milwaukee taught ten trades in 1913-14 and twenty in 1914-15, and now offers instruction in any trade requested by twelve persons or more.

The Committee on Industrial Education of the National Association of Manufacturers says in its report of 1915:

> The adaptability of the continuation (or part time) school is invaluable. Witness occasional classes for janitors of churches or school houses with splendid results; of Spanish for work-a-day correspondents and stenographers; in leather work, including cobbling; in delivery work, including the care of horses; in dietaries for poor wives unused to American markets, and of course the usual trades in wood, metal, electricity, home-making, etc., as the basis of the larger activities.
>
> Some very simple things must be taught, like fractions to those who had them in school but cannot figure in their trades.

For the public schools to provide the necessary equipment to develop manual skill in any such exten-

sive list of trades would be enormously expensive and would be merely duplicating equipment which is necessary in industry for regular production.

On the other hand the employer has no direct use for equipment for teaching theory, while the schools must have this for other purposes, even if they give no vocational instruction.

248. In education in trades an important difference exists between men and women, in that women usually remain a few years only in industry. Time is therefore lacking in which to recover the cost of developing them to great ability. The Ideal in teaching them should be to give them moderate skill quickly. Men will repay the necessarily slower development to a high degree of skill.

249. In connection with compulsory attendance of young industrial workers for part time in public trade schools, the following extract from the 1915 report of the Committee on Industrial Education of the National Association of Manufacturers, is of interest:—

> Wherever tried, compulsion finds ready acceptance. Some employers complain at first, and in harsh terms, but after a little consideration the strongest objector is prone to say, "Oh, well, if others are doing it, I am glad to. Something of the sort must be done anyhow." In Wisconsin, under State wide compulsion for all cities of more than 5000 population, no complaint on any score from employers, parents, labor or children has been made to the State Board in fifteen months. The Wisconsin experience is still of special value because there is state-wide compulsory attendance in cities of 5000 population and over, and at the end of three years the work seems to have no essential limitations except those inherent in the elements of newness and growth.

250. In this country the situation which usually confronts the employer is that of having no trade school of any sort to help him in the instruction of his work-

ers. Analytical investigation by the methods explained elsewhere in these pages will show the amount of inefficiency due to ignorance of theory, the feasible money saving which can be effected by instruction therein, the cost of such instruction, and therefore whether it will pay the employer to provide it himself.

With the diversity that now exists in industries and the amount of division of labor commonly practiced, instruction in practice and manual skill usually gives a worker a special fitness for a particular plant; and, if combined with the application of the Fair Deal and Efficiency Reward, increases the probability of his staying there.

On the other hand, instruction in theory broadens one's usefulness, and therefore increases his ability to work elsewhere. It is an observed fact that people usually develop an affectionate loyalty for the place, institution and person from whom they receive instruction which interests them, and by which they consciously benefit. I think that this consideration would overbalance that of broader opportunity, so that instruction in theory as well as in practice would tend to permanence of personnel, but I have no statistics by which to confirm this idea.

At any rate the probable feeling of the employer that, in providing instruction in theory, he is making his help more likely to leave him, is a good reason why this instruction ought to be provided by Government.

251. Instruction is helped all along the line by the application of Standards, Planning and Despatching, and Records because, as is explained in Articles 129, 131 and 134, the weak points are thus made apparent, so that it is known exactly to what men, machines and processes special attention should be paid.

252. In the usual industrial plant, a foreman nearly faints if a skilled man threatens to leave, while a good foreman is equally able, by the same threat, to give spasms to the factory manager.

In war, a regiment will lose half its men; will come out with a lieutenant, or even a sergeant, in command, and still be able to manœuvre.

The reason for the difference is that the military organization, being made to be shot at, has for every position an understudy who is instantly available; while industry, being comparatively free from casualties, has neglected this need and has in consequence developed a weakness which is likely at any time to affect it disastrously.

The strength (amounting almost to indestructability) that a good system of understudies gives to an organization, is shown by the example of a regiment under fire. The development of understudies is equally possible in industry with just as valuable results, and is fully practiced by the Pittsburgh and Lake Erie railroad, by theatrical companies, and perhaps by other American industries.

The normal understudy is the next subordinate in the Chain of Command. This has two advantages:—

The understudy has opportunities continually to observe his superior in the performance of his duties, and therefore requires little instruction in them;

Other persons regard the understudy as the natural successor and therefore accord to him temporarily the higher position, more willingly than they would to any one else.

Nevertheless industry should not blindly practice seniority promotion, but should select the fittest, regardless of seniority, provided the superiority of the

one selected is more than sufficient to compensate for the loss of the advantages above stated.

If the plant has an employment supervisor, the selection of understudies is properly his job, subject to advice and approval the same as in filling a position. See Articles 44 and 45.

Whoever is selected as the understudy ought to be definitely and publicly known as such.

The understudy while acting in the higher position should confine himself strictly to routine matters. For example, a straw boss acting temporarily as foreman, would be expected to do nothing more than carry on the work in process, and should not even be allowed to make requisition for the purchase of new equipment or otherwise to disturb any of the permanent conditions of the department.

If the activities of the understudy are thus limited, and his regular work enables him to observe the work of the higher position, about all the additional instruction needed is fairly frequent practice in its routine duties. This can often be given with benefit in other directions. For example, some plants hold foreman's meetings out of working hours and require the foremen to attend these without additional compensation. This is a hardship to the foremen and an unnecessary one because, if a sub-foreman, straw-boss, or leading workman were selected as understudy to every foreman, these understudies could perfectly well relieve the foremen temporarily, and by so doing they would gain experience which would form them into a reserve from which foremanships could be filled on short notice.

253. Kimball summarizes the situation with reference to Correct Methods and Instruction as follows:—

It pays to *teach* men the best methods by which work can be done. This is in strict accord with all human experience; yet the backward state of the educational side of factory management is startling. Even the much lauded old apprenticeship systems were not, as a rule, educational in a true sense. The apprentice was given an opportunity to learn by observation and absorption, but was rarely taught. Is it any wonder that the accumulated errors and wasteful methods of the trades have persisted? If time and motion study have done no other service than to call attention to this fact they have rendered a great service. It is rapidly becoming recognized that increased refinement in methods and higher requirements for the worker can be met only when coupled with proper methods of instruction. It is not sufficient to set standards that only a few men can reach to the arbitrary exclusion of all others. Every man should be educated industrially to his highest capacity, in the work for which he is best fitted, and every man should be given an opportunity to produce to the best of his ability and rewarded accordingly. This implies not only a changed point of view on the part of our public schools, but on the part of factory management also. The work of Mr. H. L. Gantt in training men not only in skill, but in habits of industry, is worthy of special attention. The setting of standards of performance means very little, after all, unless these standards are high. And if they are high they can be reached by the majority of workmen only after careful training and preparation.

Chapter XII

THE FAIR DEAL

254.

ONE of my most valued friends began work when about fifteen years old as an apprentice in a machine shop. One of the most remarkable things that I know about him is that, as a young boy, he had the moral courage, determination, and ambition to set himself to study and learn, not only the practice but also the theory of his work.

He kept his books in his tool locker, and when he had a long cut going on a machine he would get out one of his books and study. He saved his money and took a course in an engineering college, and has since had a varied but ever upward career; having been in turn a designing draftsman, a professor in a great engineering college, and manager of a large plant, until now he enjoys a national reputation and is filling with success and distinction a position of high importance.

I mention these facts to show that experience has qualified him to be a good judge of human nature in industry from the top to the bottom and in all its varieties.

He said to me once, "These people who are always talking about the working man as if he were some

kind of a bug, to be caught with a net and examined under a microscope, make me tired. The working man is just a human being like anybody else. If anyone wants to know how the working man would feel about anything, let him ask himself, 'How would I feel about it?' "

255. Gantt says:

It has become an axiom in the commercial world that in the long run those transactions most promote prosperity which are advantageous alike to buyer and seller. It is coming to be realized in the industrial world that the same thing is true regarding the arrangements between employer and employees, and that no arrangement is permanent that is not *regarded by both* as being beneficial. In other words the only healthy industrial condition is that in which the employer has the best men available for his work, and the workman feels that his labor is being sold for the highest market price. The employer who insists on more service than he pays for, and the employee who demands excessive wages for his work, both lose in the long run. The former worries continually about how to manage dissatisfied workmen, who are continually on the verge of a strike, and in dull times the latter lives in constant dread that his employer may no longer be able to continue business, and he may be out of work. In other words, unless efficient work goes with high wages, the result is apt to be disastrous to both employer and employee.

Gantt's statement may be summarized as a demand for the Fair Deal; and the Fair Deal both ways, from the employer toward the employee, and from the employee toward the employer.

256. In practice we find, on the part of the employer, everything from the most cruel exploitation, which is ethically little, if any, better, than holding one's fellow beings in slavery, to outright paternalism; and, on the part of the employee, everything from the most arbitrary and tyrannical interference with the management of the business, to abject submission to sweating.

257. Civilization learned a good while ago that slave labor did not pay, and the general experience of efficiency engineers is that low wages mean high costs of production.

On the other hand some of the concerns which have done the most in so-called "welfare work" for their employees have had the most trouble with them.

Suppose we apply to this puzzling situation my friend's test question, "How would I feel about it?" and put ourselves in the worker's place.

258. Suppose now that our pay envelope, hitherto containing ten dollars a week, we find to contain twelve. How do we feel about that?

During recent winter mornings, I often noticed a certain undersized working girl on her way to the factory. She had several blocks to walk after she left the car, and the weather was often sloppy. I noticed that she never wore rubbers. In bad weather that meant wet feet by the time she got to work. A dollar more in the pay envelope would have meant to that girl a pair of good tight rubbers, dry feet through the working day, freedom from colds and better health all around. If she had had the extra dollar soon enough to have allowed her to have more nourishing food earlier in life, probably she would have grown bigger. More money in the pay envelope means just that—the provision of things that it is painful and even dangerous to do without, but which one cannot have if he is limited to a bare existence, and for the lack of which he finally pays the penalty with life itself.

Does the employee object to more pay? On the contrary he will work in dust and dirt that will kill him in a few years, will engage to go to the North Pole or to take photographs on the firing line, or will work in a

coal mine where other men have perished by the hundred in one disaster; all for more pay.

259. Suppose that our employer puts in a first aid room and employs a nurse in constant attendance. Last year we cut a finger. It did not amount to much and we gave it no attention for several days. Then instead of healing it became sorer and sorer. We do not know anything about infection; but we know that before we got through with it we were carrying that arm in a sling, that it hurt so much that we could not sleep at night, and that for several weeks we were unable to work. Now we get another cut. Our foreman sees it bleeding and at once sends us to the first aid room. The nurse cleanses the wound, dresses it and tells us to come back the next day for a new dressing. In two or three days the wound is healed, we have lost no sleep and we have not had to lay off with an arm in a sling.

What is our attitude toward the nurse and the first aid? Has it decreased our wages? Compared with our previous experience it has evidently increased them. Probably we do not think it out any further than that; but if we do, we remember that when we came back last year, we found our machine in bad condition and a lot of spoiled work around due to the incompetence of the men who had been hurriedly hired off the street to take our places. We perhaps realize that they cost the employer a good lot of money beside their wages, and that avoiding that kind of thing saves him more than enough to pay for prompt attention to our injuries, and therefore increases rather than decreases his ability to pay our wages. Do we object to the nurse and the first aid room? Answer it for yourself.

260. Suppose that our employer hires a band to play in the shop during the noon hour. The men like the music but some workers remember that last Sunday their wives wanted them to take them and the babies to the park to hear the music, and they did not have the money. What do they think? Very likely, "Give us our share of what the band costs, in our wages, and let us spend it to suit ourselves."

Or suppose we are employed by a devout adherent of a different religious persuasion from our own. He employs a welfare worker who visits our homes and leaves tracts in our own language for our families to read. How do we like that?

261. What then constitutes the Fair Deal?

Two great teachers have independently given almost the same answer. Buddha taught his followers to do nothing to others that they would not be willing to have others do to them. Christ stated the same thing in positive and therefore stronger form, "All things whatsoever ye would that men should do to you, do ye even so to them."

Their generalizations are perfect and, like all perfect generalizations, difficult to apply in the particular case. Any man needs a sense of justice, tempered by human sympathy and kindness, checked by Higher Common Sense, and guided by Competent Counsel, always to answer rightly.

However some notes from experience in industrial management may be helpful.

262. In the first place, wages should be up to the market rate. Wages are really the crux of the whole matter. If the pay is good, employees are likely to overlook other defects in their condition; but poor wages are likely to cause such a feeling of irritation

that benefits in other directions will be regarded as a cheating substitute.

Bonus and other additions to the market rate of wages come under Efficiency Reward, not under the Fair Deal.

263. In the second place, conditions should be as safe and sanitary as is commercially possible. This means more than is ordinarily supposed. The Pittsburgh and Lake Erie Railroad, a shining example of efficiency and low operating costs, in its yards at McKee's Rocks, has a white blacksmith shop whose interior is of the color of fresh whitewash; but it is because the strong blast in the forges and the hoods over them cause the smoke and gases to pass off at once through the stacks, not because of frequent whitewashing, that the place stays white.

The Pittsburgh and Lake Erie finds that, paying the market rate of wages, as it does, it can have the pick of blacksmiths and their helpers, partly because of the better health which their men enjoy from working in air fit to breathe, and partly because of the courteous treatment that the foreman gives his men.

264. In the third place, there should be human kindness; recognition that employees are sentient beings and not mere machines of flesh and blood. Even the horse works better if he is spoken to by his name and in a kindly tone.

If an employer buys labor merely as a commodity, with no more feeling than he buys coal, he can expect to get just as much loyalty from his workers as he would from a coal pile with some sticks of dynamite scattered through it.

Repeatedly in these articles attention is called to the importance of team work. No one would expect team

work from an athletic organization whose members were not loyal to each other and to the management. Nothing different can be expected from an industrial organization.

Human nature is so social that we involuntarily feel a bond of sympathy with a fellow townsman or with a neighbor. If this natural social loyalty is not developed among those who work in the same plant, one element of efficiency is therein conspicuously neglected. Whatever methods and devices are locally used to foster this loyalty, it is fundamentally a matter of the spirit.

No matter what systems may be followed, in thousands of ways the inner spirit of the management will leak through, and will be felt by the workers; and they will ultimately reciprocate, whether it be kindly, indifferent, or hostile.

265. On the other hand, experience in efficiency work shows that one of the surest means of winning the employees' confidence in betterment measures, is to explain to them that such measures pay the employer, and how and why. If they are convinced of this, the sting of patronage is taken out, and the workers feel that the improvements are undertaken on a business basis, in good faith, and will be permanent.

266. This may be summarized by saying that throughout betterment work a spirit of enlightened altruism and one of enlightened selfishness must meet and be perfectly reconciled, as is indeed the inevitable outcome if both are perfectly enlightened.

267. The fourth element of the Fair Deal is absolutely dependent upon the employer. This is the assignment of workers to the tasks for which they are fit. The Emerson Company has probably done more

work along this line than any other general betterment practitioner, and their experience indicates that over half of all industrial workers are in work for which they are less suited than they are for other work in the same plants.

An article entitled "Ford's Material and Labor Systems" in the *Engineering Magazine* for May, 1914, states that Ford is giving particular attention in his plants to finding workers who have abilities other than for the jobs on which they are employed, and to connecting them with the work for which they are most fit. The writer cites some very interesting cases; for example, a skilled Swiss watch maker, who was found running a drill press.

The means of doing this important work are stated in Articles 44, 45, 47 and 48.

Why does not the worker himself see to it that he gets work for which he is fitted? He cannot. He does not express himself. Silence he regards (and with considerable reason) as his safest policy. He will not tell you about himself or anything else ordinarily, unless you not only invite, but considerably encourage him to do so. Any man who has ever looked for a job will remember that his range of choice was very limited, and that he took the best that he could get. Once started along a certain line, one soon develops a little skill which increases his earning power in it and makes him reluctant to start over at beginner's wages in another line, even though he may feel that ultimately he would do better in it. He gets into a rut, and it is very hard for him to get out; the harder, the less his resources.

268. A necessary condition for the successful application of the Fair Deal is that Higher Common Sense

and Competent Counsel should be used to determine what is fair.

Recently I had a conference with an industrial manager whose directors prohibit time studies in their plants, refuse to use any methods of payment except time rates and piece rates, and expect their manager to increase the efficiency.

In this dilemma he had recourse to records of past performance as his only means of setting standards, and had used these as the basis of piece rates, with guaranteed minimum time rates.

The direct workers had just begun to take hold of the piece rates, and the manager showed me records of several earnings of twice the man's regular daily wage, and one of 5.17 times that wage.

Unless the directors act with an enlightenment not at all to be expected from their previous unreason, their next step, as soon as they learn of these big piece-rate earnings, will be to force the manager to cut the rates, although the rates as they stand decrease their previous labor costs.

That is universal experience where standards are set without previous adequate determination, *not of what has been done but what can be done.* The workers first hang back, then discover the possibilities of big earnings and go ahead and make them. Then the employer gets scared at the wages he is paying and makes the standards more severe. The workers, finding that they will be allowed to earn only so much any way, refuse to try for anything above that amount.

No effort toward a more equitable division of wealth produced, between direct and indirect producers, can be permanently successful unless results in the long run are evidently substantially fair to both parties;

and this can be accomplished only by basing the division upon correct Standards.

269. It is necessary to emphasize the Fair Deal from the employer to the employee more than that in the other direction, because the employer has the advantage of position. He needs the employee in order to make money, the employee needs him in order to live. This fact gives the employer a strength which his employees, even when combined in the strongest union, find it difficult and often impossible to resist.

The weak must adapt their conduct to that of the strong. If the strong desire to oppress, the weak have no safety except in combining to fight in self defence. Nevertheless, war measures are very heavy burdens; therefore, no nation, union or individual will carry them permanently, except as a necessary protection against a recognized danger.

Therefore only the strong who need not fear can lead off in the practice of the Fair Deal; but the weak, perhaps slowly, reluctantly, and timidly, but inevitably, must follow their lead.

270. This of course is speaking of men and women in mass. It is to be feared that in any considerable number of people, at least a few abnormal individuals will not respond but will maintain a hostile attitude. These people are always a source of danger. Causes of irritation can never be absolutely removed from the mass, and the least of these finds in the malcontents infected spots from which trouble can spread. Probably these people are curable; but the industrial plant cannot be expected to be a psychopathic hospital. For the industrial manager the only practical remedy is prompt and adequate Discipline.

271. I once took part in an extensive preliminary

investigation in a plant which paid piece rates almost exclusively, and in which those rates had been cut and recut.

The feeling of the direct workers toward the management was very bitter, and their distrust so great that the investigators did not dare to show a stop watch in the work rooms, and the appearance of any of us was the signal for all to slow down.

Where such a condition exists, it is wise to work at first on other things than labor; and the management must meanwhile experience a change of heart and convince the workers of it by bringing forth fruits meet for repentance. In other words the evident application of the Fair Deal must, in such a case, be the first of all betterment measures to be applied to labor.

Even then one must not expect to gain the confidence of the workers quickly, no matter how benevolent his intentions may be. If toward the close of the deer hunting season, one were to go into the woods with a bag of rock salt, and the best intentions in the world to give a lump to every deer, he probably would not get within a mile of one of them.

Evidently nothing but time and patience will overcome these difficulties. Failure may be caused by trying to cram improvements down the throat of the organization faster than the latter can swallow them.

272. However, the benefits of efficiency, so greatly to be desired by all parties, will be much more quickly obtained if employees also realize that, to secure them, they, too, must practice the Fair Deal.

As Gantt says:

> Increase in efficiency makes the payment of high wages possible, and it may be added that without efficient labor, high wages cannot be paid indefinitely, for every wasteful oper-

ation, every mistake, every useless move has to be paid for by somebody, and in the long run the workman has to pay his share.

273. Nor can the maximum efficiency be attained unless society, the third party in all this, gives a Fair Deal to both employers and employed and does its share of the work in ways that are stated elsewhere in these articles.

The Fair Deal comes to the front in the matter of promotions. How often, when an efficient man in a lower position is suggested as the proper person for promotion to a higher one, do we hear, "He's a very good man where he is, let him stay there!" If the man thus unfairly treated were a mere machine, without mind to know and feel the injustice, this might be sensible.

Efficient work in one position is in itself a claim on advancement, which can be nullified only by evident unfitness for the higher position—either absolute unfitness, or unfitness relative to some other candidate.

If Standards and Records have been applied and if the fittest men as shown by them have been developed as understudies, as suggested in Article 252, almost every vacancy will be filled automatically, by the promotion of the understudy.

Chapter XIII

DISCIPLINE

274.

WHATEVER may go into the superstructure of a building—wood, paper, glass, and cloth—nothing but stone and steel will do for the foundation.

With whatever kindliness the outward manifestations of an organization may touch the individual, strength to achieve is lacking, unless there is a stone and steel foundation of *obedience to orders.*

Yet one would not have to search far to find American plants in which implicit obedience to proper authority is not even expected.

To some extent this is due to a lack of backbone on the part of the management, as a result of which it weakens at the least threat of difficulty.

In any community the maintenance of proper Ideals occasionally requires the exemplary punishment of those who violate them; and the industrial manager, as much as any other in authority, must expect to practice this, if he is to achieve high efficiency.

275. One reason why military discipline can reach with such strictness into the smallest details of a soldier's life, is that the military commander can inflict penalties of all grades of severity, suited to all grades of offences. It would be absurd to courtmartial a

soldier because he came to parade in a dirty uniform, and it would destroy discipline to do anything of the sort. Martinets are not good disciplinarians. A brief confinement in the guard house, or the temporary loss of some minor privilege, deals effectively, because appropriately, with a minor offence.

The industrial manager is often hampered by lack of any penalty except discharge. As this is obviously too severe for small offences, and has a good deal of a back kick to it against the business itself, a foreman or other executive is reluctant to apply it, and in preference is apt to tolerate a good deal of disrespect, untidiness, and other things that ought never to be allowed.

In the theatre cash fines of varying severity are successfully used to maintain discipline. They would doubtless be equally effective elsewhere; but there are obvious difficulties in their general application to industry, one of the most serious of which is the likelihood of their being abused.

Docking an employee's pay for absence is simply not paying for value not received, and therefore is not a punitive fine.

A lay-off without pay, for a length of time proportioned to the gravity of the offence, is commonly practiced, and is effective; but where there is considerable division of labor, the absence of a worker may be so troublesome as to make the executives over-reluctant to enforce this penalty.

The obvious remedy for this condition is the development of understudies, which is discussed in Articles 44 and 252.

A demerit system immediately provides small change in penalties. Such a system is a kind of book-keeping

applied to conduct, whereby debit entries are recorded until they reach an amount large enough to be worth collecting by the infliction of a penalty appropriate to the sum of the offences. By this means offences too small to be punished by themselves, collectively bring upon the offender an appreciable punishment.

Obviously much of the effect of a demerit system is dependent upon its being publicly known that such and such an offence will bring so many demerits and that, as surely as one receives a certain number of demerits within a given time, he will suffer a certain penalty.

It would require considerable tact to introduce a demerit system with published information of recognized offences, demerits due to each, and standard punishments, without arousing perhaps resentment and almost certainly ridicule.

The same results can be accomplished without these disadvantages by the installation of the records of employees suggested in Articles 47 and 138, including reports by executives to the employment supervisor on their subordinates. A man might be disrespectful to his foreman one week, spit tobacco juice all over his machine the second week, and knock over a truck load of work in process the third week, and the foreman's resentment of each might be so much abated before the next occurred, that he would fail to punish any of them; but if he had to report on the man every week to the employment supervisor and his successive statements ran "fresh," "dirty," and "careless," and the employment supervisor was onto his job, something would be pretty likely to happen to the man. If this should occur after Records, Standards, and Planning and Despatching had been introduced, and the man's record showed that he had been from two to ten min-

utes late every morning and that his efficiency was only 75 per cent, his connection with the concern would be likely to end.

276. A friend has told me of a recent visit to the employment department of the Ford Motor Company during which a workman was called in to answer to an inspector's report that he did not properly support his family. After a hearing, the employment supervisor suspended him from the bonus class until he should take proper care of his family. Here we have a man brought up for something which most employers would consider as none of their business, and accepting as punishment a drastic cut in his wages, which would cause almost any workman to quit his job on the spot.

Why could Ford do this and why should the man stand it? Because the man valued his job; and he valued it because it was valuable. Even under the cut, he probably earned as much at the Ford plant as he could earn anywhere else; and he knew that by doing his duty he could get back to five dollars a day.

Obviously, in order that the employer may be able to punish effectively, he must cause his employees to value their jobs, and the only way to do that is to make the jobs valuable. At this point Discipline connects closely with Adaptation of Conditions (see Article 50), the Fair Deal and Efficiency Reward.

277. Captain Marryatt's stories of the British Navy of one hundred years ago represent the officer on watch as peremptorily ordering the immediate punishment of offenders, without any reference to higher authority. Substantially the same condition existed in the American Navy at that time. Naval discipline has always been renowned and is better now than it was then. One

of the causes of its improvement, in the American Navy at least, is that the power to punish has been taken away from the officer immediately in contact with the offence and the offender, that subordinate officers can only report offences to the captain, that the latter can inflict only minor punishments, and that severe punishments can be inflicted only after trial and sentence by a court martial.

In industrial discipline, we are still in the main where the American Navy was one hundred years ago, in that the foreman still has absolute disciplinary power, even to discharge.

Discipline can not be permanently maintained, unless it usually achieves substantial justice; that is, the Fair Deal. Common Sense indicates that the official against whose authority an offence is committed is more or less affronted by it, and is not in a mental condition fit to judge the case; and that all serious cases therefore ought to be reviewed by some one removed from such influences and capable of a judicial and wholly impersonal attitude.

The employment supervisor is the natural person for this function. His duties in this respect are discussed in Articles 45, 46, 47 and 48.

At the same time, in an industrial plant, the immediate object of discipline is primarily to enforce proper authority and to keep the work going, and secondarily to give a Fair Deal. In other words, a workman accused by a foreman should be assumed to be guilty until he proves that he is innocent. In reviewing disciplinary actions, the employment supervisor therefore works under certain restrictions which should be noticed in the reference above given. However, arbitrary and unfair conduct of an executive ought as

soon as possible to bring down Discipline on him, on which see Article 46.

278. One violation of discipline is so commonly practiced by higher industrial officers that it must be noticed. Many superintendents and managers will go into a shop and deal directly with the workmen, often giving them orders of which the foreman has no knowledge, or even reprimanding the direct workers for doing what the foreman has told them to do. This sort of thing diminishes the foreman's authority and correspondingly increases his difficulties. Only in an emergency should orders be given, except through the Chain of Command; and where such emergency orders are given, the intervening members of the chain should be notified as soon as possible.

Adherence to the recognized good practice of avoiding oral orders, and giving them, if possible, only in writing, will remove most of this difficulty.

279. While occasional punishment may be as necessary as a steel and stone foundation, discipline that is nothing but punishment, is like living in the cellar. Life above ground, where there is more light and air, is both pleasanter and healthier. In any efficient organization, the people think as seldom of punishment as any well regulated family does of the coal hole.

280. It is possible even in a prison to maintain discipline that is at once effective and loyally supported by the general mass of those subject to it. This is so much more possible in an industrial plant, that any concern that does not have it ought to give its internal affairs very serious attention. It would be well to read again at this point, Article 32.

The effect of instruction in producing loyalty is noted in Article 250. Hunter says:

> How about loyalty? When a boy starts an apprenticeship course and grows up he will certainly be loyal. If he serves his time with Brown & Sharpe, for instance, later when he goes out he will talk for Brown & Sharpe and the things he saw there. We have found this to be true.

The reason for this seems to be that through instruction the person is given skill, that in the exercise of this skill he finds pleasure, and that this pleasure causes affection toward the place, institution, and person to whom the skill is due.

H. E. Miles, reporting as Chairman of the Committee on Industrial Education of the National Association of Manufacturers at the 1915 meeting, said:

> Do we wonder that our workers are not more happy? Were you ever happy in doing a thing that you did not know how to do? Were you ever happy in doing a thing that you only half knew how to do? There is only one way to make working people happy and that is to make the work they do intelligent. The minute you make work intelligent and make a worker good and expert at his job you will have no trouble in filling the shops with happy workers.

Adaptation of Conditions and Work to Each Other, including the placing of the worker in a job for which he is naturally fit, should be noted as a cause of loyalty. See Article 50. The astonishing number of human misfits in industry, as mentioned in Article 267, is a probable and removable cause of unhappiness, disloyalty and poor discipline.

The effect of the Fair Deal in producing loyalty is noted in Articles 264, 265 and 266. When all these causes of loyalty have been put into effect, the substructure of discipline is so covered over by the more attractive superstructure, that loyalty, not fear of punishment, becomes the dominant feature of discipline.

Obedience then springs not from fear, but from loyalty; and while fear can usually compel a perfunctory obedience, zeal and willingness, and that team work whose importance has been so often emphasized, spring only from loyalty.

Chapter XIV

EFFICIENCY REWARD

281.

IN all ages soldiers have carried efficiency to that extreme of self-devotion in which a man exposes himself to death in its most horrible forms, for rewards without material value. Many a man has risked his life, and lost it too, in the hope of being mentioned in general orders.

Why is it that an intangible and merely sentimental reward is effective under such extreme conditions?

Neither the commander-in-chief who bestows the reward nor the country which he represents, profits in any selfish way by the act for which the soldier is rewarded. On the contrary, when the soldier devotes himself for his fatherland, he believes that all whom that fatherland includes are under equal obligation to practice the same devotion to the limit of their opportunities.

Where all sacrifice and suffer together for the common good, those who excel may be effectively rewarded by honors of no intrinsic value.

282. Where many toil for the profit of a few, those few cannot effectively reward efficiency except by substantial material value.

283. Nevertheless sentimental rewards are practiced

in industry. Workmen have been divided into gangs according to their national and other rivalries, one gang of Italians and one of Slavs, for example; and the flag of the gang that did the biggest day's work has been floated over them both on the next day. Records of efficiency have been posted, where all could see and admire or condemn. The picture of the best salesman has been published in the house paper with a commendatory notice. "Banner Section," or words to that effect, have been posted in gold letters six inches high on the tool house of the best section gang, for the edification of passengers on the railroad.

These things have their value in industry, only if they are used as mere accompaniments—spice and seasoning, as it were—to efficiency rewards of substantial value. It would be well in this connection to reread Articles 31 and 32.

284. In industry, the final measure of efficiency is the dollar. No supposed improvement which does not finally result in a lowering of unit cost really increases efficiency. Therefore before any form of efficiency reward is adopted, its effect upon cost should be investigated. A hypothetical example of this is given in Table 15 under "Labor," and is explained in Article 376.

285. Referring to Figure 1, Article 66, Diagram of Typical Organization, team work is of supreme importance in the case of the Financial Manager, the Sales Manager, the Factory Manager and the Chief of Staff. For example, we all know the pressure on the sales department for minor variations in the product, and the high factory costs which result from yielding to this pressure. On the other hand a lowering of quality by the factory might result in a considerable

decrease of factory cost but also in a loss of reputation which would greatly decrease sales. Therefore, the efficiency reward of these men ought to be such as will cause them to work for the business as a whole, as much as for their own branches; and for this purpose there is probably nothing more effective than outright profit-sharing.

Profit-sharing has the further advantage that it is not affected by errors in setting standards; for example, referring to Table 7, Article 184, the appropriations and standard allotments.

Profit-sharing also has the advantage that it can be started immediately; and, for reasons that are stated in Article 184, it is desirable that efficiency reward for the executives should be started as early as possible. As a matter of Fair Deal, the executives are entitled to an efficiency reward, for any efficiency that is attained must be due, in a large measure, to their sympathy with the work and their labors in advancing it.

286. As we go down the Chain of Command, profit-sharing at every successive link loses in effectiveness as an efficiency reward, until, when we reach the direct workers, it is practically valueless.

The reasons for this have been so fully explained in the general literature of the subject that I shall here only summarize them by saying that there is no real connection between the profits of the business and the efficiency of the individual worker at the bench or the machine, and that he knows this perfectly well.

Even if this were not true, profit-sharing as an efficiency reward is in time too remote from the act rewarded, to be effective. My own experience with machine operators is that, if even four weeks intervene between the work and the reward, they do not mentally

appreciate the connection between their efficiency and the reward that is paid them. My experience of this matter has not been sufficient to warrant a generalization as to the time interval allowable; but certainly all experience has shown that, with men of this class, both rewards and punishments must follow very closely upon the act, to be fully effective in determining motives for future conduct.

287. We may therefore say that, for the men at the head of the staff and of the several branches of the line, outright profit-sharing is the proper efficiency reward; with the direct workers, profit-sharing is useless, and their efficiency reward should be based on their own efficiency and should follow as closely as practicable thereon; and that, in between, profit-sharing, diminishing with every link that we go down in the Chain of Command, should combine with other efficiency rewards based on efficiency for which the individual is personally responsible, and increasing in relative importance with every link that we go down.

288. A superintendent or foreman might therefore receive several efficiency rewards. For example, referring to Table 7, page 200, the foreman of Department 1 might first have a small share in profits. He ought to get the bulk of his efficiency reward for reduction of costs over which he has large, and possibly complete, control. The reduction of direct labor for his department from $75 000 to $63 000 per year is very largely dependent upon him. His department being one of first operation, its share of the annual appropriation of $260 000 for direct materials will perhaps be $200 000, so that his standard allotment for direct materials would be $180 000 per year. It might be possible also to segregate the power consumption for his depart-

ment and give him an appropriation and standard allotment for it. See Article 129.

It may be possible to give him appropriations and standard allotments on other indirect expenses. The foreman ought to get the bulk of his efficiency reward for such definite reductions of expenses. This will probably be some form of commission on the amount by which he reduces his actual expenses below their respective appropriations.

Since fluctuation of production is likely to occur and produce corresponding fluctuations of the appropriations and allotments, it is convenient as soon as efficiency rewards for the direct workers have been installed, to put the foreman's commissions on savings in direct labor and direct material into the form of percentages on efficiency rewards earned on direct labor and direct materials by the direct workers of his department, since these last will depend directly upon the volume of production as well as upon the efficiency, that is, they will depend upon the savings. A foreman may also receive other special forms of efficiency reward. An example of this is given in Article 303.

One should not tie himself down to any cut and dried rules for the efficiency rewards of executives of the grade of superintendents and foremen, either line or staff, because their rewards should be worked out according to circumstances, so as to induce the highest efficiency in the case in hand.

However, on starting any form of efficiency reward to such an executive, it is necessary to look ahead as far as possible to all the efficiency rewards that he is to have, in order to design them so that their total amount will be reasonable and their proportions to each other such as to produce efficient results.

289. In practice, the proportion of efficiency reward to time rate for executives varies enormously. With all efficiency rewards in operation, and efficiency at 100 per cent, the minimum ought to approximate 20 per cent of time rate. According to a statement in the New York *Herald* for September 27th, 1915, the efficiency rewards of the fourteen managing directors of the Bethlehem Steel Company vary from 1800 per cent to 18 900 per cent of their time rates. It may be profitable to pay anything above even those figures, according to the amount of savings in sight and the difficulty of obtaining them.

290. In considering the subject of efficiency reward for direct workers, it should be remembered that the employer really buys two things from the worker; first, an option on the latter's time, and, secondly, his output. The reality of the option on time is apparent whether we look at it from the stand-point of the employer or the employee. The former, even if he is paying piece rates only, objects to absence, and rightly so, since it disturbs the balance of his force on the various operations. The employee, if he is sent home for lack of work, will hardly find it possible to sell this brief portion of his time. The Fair Deal, therefore, requires that as a minimum compensation, the worker should be paid for his time at the market rate of wages. In Figure 6 (page 292), time rate would be represented by the straight line *OA* passing through the origin; and total earnings should never fall below this, except as punishment for a breach of discipline. See Articles 276 and 277. Compensation on output, or piece rate, being constant for any given job and independent of time worked, will be represented in Figure 6 by the straight line *BC*, parallel to the axis of time. A fair piece rate

evidently ought to be such that earnings at 100 per cent efficiency would be the same by either method of payment. One hundred per cent of efficiency should therefore occur at *D*, the intersection of time rate and piece rate. A better than average worker who could do the job in less time than *BD*, ought not to have his compensation thereby diminished. That is, he ought to be paid the piece rate and receive the full compensa-

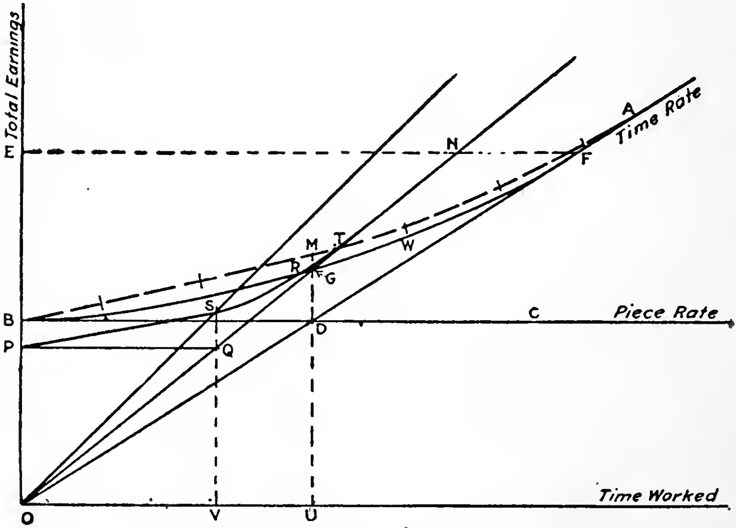

FIG. 6. GRAPHIC STUDY OF WAGE RATES

tion *OB*, no matter how short a time he works. A worker, no matter how high his efficiency, if unadapted conditions were to run badly against him (see Article 211) might require a longer time than *BD* to do the job. If he is paid the piece rate *OB*, the penalty for the unadapted conditions falls upon him; but it is the duty of the management, not the workers, to adapt conditions, therefore the latter ought in such a case to be

paid according to the time rate *DA*. Minimum compensation would then be represented by the line *BDA*, according to the length of time worked; and *DA* should represent the market rate of wages for the kind and grade of labor concerned. (See Articles 262 and 325.)

291. However, piece rate with a guaranteed minimum time rate, represented by *BDA*, is defective in that, at the beginning of betterment, the men are probably working somewhere about *A*, and the effect of the application of all the principles of efficiency is to shorten the necessary time *BD* to an extent that to them is simply incredible. The piece rate seeming to them unattainable, they do not make any attempt to reach it; and in order to get them even to try, it is necessary to put the piece rate up to a false standard *OE*, which is often very much above *OB*, and often too high for a Fair Deal to the employer, and therefore too high for permanent use. This is general experience when a form of efficiency reward is installed which consists of only piece rate with a guaranteed time rate. An example of the working of this is given in Article 268.

The possibility of installing a temporary standard, to be increased in severity later, has been noted in Article 200. Evidently this method could not usually be applied in more than a few special cases. Perhaps a management which had the confidence of the workers by long practice of the Fair Deal might apply this method generally and without trouble, but such a case can hardly be considered as more than theoretical.

Supposing that the workers require some substantial encouragement at the point *F* to get them along; without committing ourselves to the piece rate *EF*, we can give that encouragement by filleting the corner *BDF*;

that is, by paying a premium on time rate such that total compensation will be represented by the curve *BGF*.

Money payments above the time rate are commonly called "bonus," and are given that name below in these articles.

BGF will be recognized at once as Harrington Emerson's bonus curve, which it will be exactly, if *EF* equals 1.5 times *BD, DG* equals .2 times *OB, FG* is a parabolic arc, and *BG* is a straight line. It is not necessary, however, to adhere strictly to these characteristics, as they may be designed to suit the exact case in hand.

292. Other forms of efficiency reward for direct workers are, of course, in common use. All of these forms have been so fully discussed in print that it is unnecessary to describe them here. Any one desiring further information about them can find very good discussions in Kimball's Principles of Industrial Organization, and in a pamphlet of the Emerson Company, entitled "Comparative Study of Wage and Bonus Systems."

293. Even more encouragement than that afforded by the bonus curve *FG* may be necessary, when the direct workers are first beginning to increase their efficiency. Probably the best way to give this is by figuring the efficiency and bonus for every job, or every day's work separately, and paying bonus when it is earned as thus figured, regardless of the average efficiency.

When bonus is first installed, the workers will at least occasionally earn bonus on some job, or for some day's work, though they may not be able to maintain an average efficiency which would entitle them to bonus. The payment of bonus on the occasions when they do

well encourages them and leads them to try to earn it continuously.

This arrangement is obviously not fair to the employer; but it is good business for him to tolerate it, provided it is only temporary and leads to a continuous good efficiency.

There is a temptation to the workers under this arrangement to turn in their service cards or otherwise report their time before jobs are really completed, thus getting credit for completing the job in less than real time, and thereby making an apparently high, but false, efficiency. It is not to be expected that all will be able to resist this temptation.

Of course the time thus taken from one job adds to the next and lowers the worker's efficiency thereon; but when bonus is paid by the job, this sort of fraud may enable a man to earn bonus on perhaps half his jobs, while on a continuous average he could not earn bonus on any.

294. Obviously the only fair arrangement is to average the efficiency over a considerable time, usually one pay-roll period, as a basis for the payment of bonus.

The Emerson Company's "Comparative Study of Wage and Bonus Systems" says:

> It is much easier to calculate efficiencies and rewards for all the operations of the period than for each one separately, and clerical expense and effort should be avoided as much as possible.
>
> Finally, a much better conception of a man's ability is obtained from a record of weekly or monthly averages than from a list of several hundred individual job efficiency records fluctuating from 30 to 100 per cent.

295. I have known workers to object to changing from calculation by the separate job or day to calcula-

tion by the pay-roll period. The gang with which I had the experience told in Article 211, objected so strongly to having their efficiency calculated by the pay-roll period, that I never averaged their efficiency for a longer period than one day; but, after the installation of the counter, I made a practice of calculating their bonus for an occasional pay-roll period on the basis of average efficiency for the period and comparing it with what they were actually paid; and I never found the two to differ by more than a few cents.

If then conditions can be pretty thoroughly adapted, the employer runs no great risk in starting payment of bonus by the job or day, since the workers will probably settle down soon to a nearly constant efficiency and bonus; but if there are conditions which bid fair to be permanently unadaptable, the efficiency and bonus earnings on the separate jobs will be correspondingly irregular, as explained in Article 211. Under such conditions figuring efficiency by the job may mean that the employer pays the workers bonus when the luck runs in their favor, and obtains no general increase of efficiency as his own reward.

296. In such a case it would probably be advisable to pay bonus from the start only on average efficiency for a pay-roll period; and if the workers do not respond to an ordinary bonus *BGF* of Figure 6, to design a special bonus curve like *BMA*. This will, of course, commit one to the higher bonus permanently, but that is probably better than the alternative.

297. Minor difficulties may arise in keeping records of the actual and standard time, on which the efficiency (see Article 325), and then the bonus, is calculated.

I had a case of this kind in a department in which the usual job order would give a man two or three

days' work. If a man were given an order of this kind on Friday, he would be charged on that pay-roll period with all the actual time shown on his service cards until the close of the period on Saturday afternoon. To determine exactly how much every man had done up to the close of work Saturday, would have amounted to taking an inventory of the department every Saturday afternoon; and it was held that there was not enough to gain to warrant the expense of doing this. The man therefore did not receive credit for the standard time of the job, until he reported it complete with his last service card of the job, on Monday or Tuesday. He would thus be undercredited with standard time for the earlier period and over credited on the later one.

Evidently these errors would counterbalance each other in the long run, so a common way of dealing with them is to average efficiencies over several pay-roll periods, and to pay bonus on this average. In this case a four-weeks period was tried. That is, at the end of every pay-roll period, every worker's efficiency was averaged for the four weeks last past, and his bonus was figured on that average and not on the efficiency shown for the last pay-roll period alone. In this case a pay-roll period was one week.

This worked very satisfactorily in smoothing out irregularities due to jobs overlapping from one period to the next; but it soon appeared that no workman had any idea of his efficiency except for the recent past, and that if his bonus did not correspond, the moral effect of the efficiency reward was lost. I therefore had to shorten the period over which the efficiency was averaged, and finally came to two weeks as an effective working compromise.

Where any other unadapted condition brings an element of chance into the worker's efficiency, the case is similar to that stated above.

298. Another minor difficulty in keeping records of actual and standard time arises from rejections of work on inspection. On this point Knoeppel says:

> We must arrange to charge him (the workman) back with rejection for which he is to blame. The workman reports a definite production, which is figured at so much standard time per piece, on the assumption that the work will prove satisfactory and pass inspection. This does away with waiting for inspection before calculating the efficiencies, which in many cases would cause considerable time to elapse before jobs could be figured.
>
> As work is rejected a shop rejection card is made out, fully outlining whether or not the man is to be charged back with the work. Two plans are possible:
>
> (A) Deduct the amount of standard time credited to the man, leaving the actual time showing in the actual column.
>
> (B) Deduct both actual and standard time for the rejection.
>
> Plan B is not so severe on the men and can, in most cases, be used. When workmen continue to be careless, however, and are unwilling to co-operate in efforts to turn out good work, the company is then justified in resorting to plan A.

Usually pay rolls for any period are not figured until the end of the next, so that the workers are always paid for one period back. It is convenient to handle bonus in the same way. It ought then to be possible to get the rejection reports in soon enough so that the efficiencies for the pay-roll periods in which the work was spoiled can be corrected for rejections before bonus is paid.

This certainly ought to be done, because otherwise an objectionable element of chance is brought into the worker's efficiency. He may do a quick and careless job and have a large amount of rejection, which, how-

ever, may not be figured against him during that payroll period, so that his low actual time may give him a fictitious high efficiency and a big bonus. During the next period an earned good efficiency may be spoiled by the charge against him for rejections from the previous period.

299. The matter of interruptions has been noted in Article 104. Time lost by interruptions, except those short ones of minor importance that are allowed for in the standard time, is covered by the exception cards and simply does not count, either as actual or standard time.

300. Referring to Figure 6, page 292, we occasionally find already in force an excessively high piece rate.

Suppose the case to be that the men are earning 37.5 per cent more on the piece rates than the local market time rate *ODA* of Figure 6; they would then be working at about the point *N*. If, now, all piece rates were abolished and the men were put on the guaranteed minimum time rate *ODA* and bonus as shown either by *BMA* or *BGF*, they would immediately translate this action into a cut in piece rates. This might be required by a Fair Deal to the employer; but the men would not be likely to realize this; and trouble might follow.

Now, suppose that we put in instead a guaranteed time rate *OQN*. The men have now no cause for complaint because, in the same time, *EN*, they will make the same total earnings, *OE*, as before. All experience shows that if the time rate is thus raised 37.5 per cent, men can be secured for it who are at least 50 per cent better than the average of the local labor market. The next step is therefore for the employment supervisor and the shop executives to get to work

on a careful selection of men in order to secure such as are really worth the wages paid. With the understanding that the shop is to be manned with help of this kind, the standard time, instead of being made *BD,* can be made *PQ,* not over two-thirds as long. The corner *PQT* can then be filleted by some suitable bonus curve *PST*. In wage cost this will be more expensive to start than will the lower day rate and bonus curve as shown in Figure 6, by the amount that *NTR* stands above *FWR;* but when the avoiding of possible labor troubles is considered, it will probably not be so expensive in total cost. The final result to the employer is that, instead of having a total wage cost of the job averaging *UG,* he will attain the lower average *VS.*

This is also perfectly fair to the men because they had got as far as they could by their unaided efforts in working at the point *N*. Those improvements which have reduced the time of the job from *EN* to *PQ,* are due to the management and not to the men. Nevertheless the men have been given a share of the benefits such that, in working at the point *S,* they are receiving the equivalent of the time rate *OS,* which is considerably higher than *ON,* the equivalent at *N* of their former piece rate. Also the matter has been put up to them from the beginning in such a way that they had everything to gain and nothing to lose.

An exception may occur in the case of those men who, on the old piece rate *EF,* were already earning more than the equivalent of the time rate *ON*. There are not likely to be many such men, and they are the very ones whose labor is the best investment to the employer and who should by all means be retained. Their cases can probably be best attended to by working out for them individual time rates and bonus curves, which

shall give a Fair Deal both to them and to the employer.

301. Selection of men becomes unusually important in the case of an original excessively high piece rate, but it is in every case an important feature of betterment work. It may be asked why the employer should ever retain a worker of less than 100 per cent efficiency. The answer is that, with the existing supply of labor, a man of even 80 per cent efficiency is too good to be lightly parted with. However, it is up to the employer to get the best men that he can and if he can fill his shop with 200 per cent men he is foolish not to do it. But see also Article 308.

302. Attention is called in Article 331 to the importance of the efficiency of materials. It will be well to read in this connection Articles 221 and 222 also.

I have encountered jobs in which the ratio of cost of direct materials to cost of direct labor was as high as nine to one. In this case the workers were being paid piece rates—that is, they were being stimulated to save on 10 per cent at the expense of wasting on 90 per cent. It is obvious that in any case where materials constitute a considerable part of the cost of a job, the worker should not be encouraged to save on labor only, since this inevitably produces a tendency to waste materials.

The consideration which has appealed to me in this connection is that a dollar is a dollar, whether it is spent for materials or for labor; or, in other words, that what the employer wants is to reduce the money cost of a job, rather than to save either material or labor as such.

I have therefore tackled the job by determining primarily how much waste of materials should be al-

lowed. For reasons which will appear, this should be large enough to allow the worker a margin on which to earn bonus; but it may be considerably better than current practice. For example, in one case, two studies which were made independently by different observers using different methods and on different jobs, showed 31 per cent as the amount of original material that went into scrap. After careful study of the data, I set 14.5 per cent as the standard amount of waste, for reduction below which bonus would be paid. On this standard the workers earned a handsome amount on the very first bonus job.

In material bonus work, in my experience, the ratio of cost of direct materials to cost of direct labor has not been less than six to four. Hence I have desired in these cases to encourage the workers to work carefully and save materials, rather than to work fast and save time. I have therefore set the standards of time as nearly as possible at what the workers were already doing. As will appear, the form of bonus was such that the worker would earn no bonus on time if he worked just as fast as his previous habit, and would lose on his total bonus if, in the effort to save material under the incentive, he slowed down from his previous habit.

Net materials required for the job are of course known from the dimensions of the output. These, with standard waste, give standard original materials for the job. These multiplied by unit cost of the material, give standard cost of the material. Standard time multiplied by standard time-rate, gives standard cost of direct labor. Standard labor-and-material cost of the job is thus obtained.

In some cases valuable by-products may be produced.

The material service card should then record amount and value of this by-product. The standard value of the by-product then subtracts from standard labor-and-material cost of job as figured just above.

The jobs then go to the workers with a standard total labor-and-material cost. Records are kept of the costs actually achieved. See Article 114. The value of the by-product actually produced subtracts from the total actual labor-and-material cost.

Standard total cost minus actual total cost gives the gross saving, and the workers on the job are paid a percentage of this as their bonus. In my experience bonus has had to be between 20 per cent and 33.3 per cent of the gross saving, in order to secure the co-operation of the workers.

This form of bonus has the advantage of being simple and easily calculated, of being so flexible that it is adapted to all sorts of conditions and jobs, and to men who work fast and save time, just as much as to those who work slowly and save materials.

Before installing this form of bonus, I have explained it to the workers, and have taken care to point out to them that they were most likely to earn bonus, not by hurrying, but by working carefully and saving materials, and by taking as much time as they needed for that purpose.

The immediate result has been a reduction of waste of materials, with time remaining substantially the same as before; but later some slight reductions of working time have also been made.

303. It is sometimes desirable to bonus a worker wholly or in part on the work of others than himself. Bonus to instructors (Article 235) and to foremen (Article 288) based on the efficiency of those under

them, hardly comes in this class, since it is properly the work of the foremen and instructors to maintain this efficiency. Sometimes the efficiency of a worker is very dependent upon the condition in which work comes to him from a preceding operation. It is then proper to bonus those who perform the earlier operation, in whole or in part, on the efficiency attained on the later one.

Gantt gives an illustration of this as follows:

> Inspecting cloth and mending slight defects in weaving, trimming ends, etc., . . . is high grade work and all defects must be eliminated. We started the task after careful study, . . . These inspectors were supplied with work and had the heavy cloth handled for them by three men. . . . Each of these men received two cents for each girl (inspector) that made a bonus. Early in July it was decided to give the boss weaver . . . a bonus. He is an excellent man and was undoubtedly doing his work well, but we felt that his bonus should depend upon the quality of the work turned out. Inasmuch as the better the cloth was when it came from the weaving room, the easier the task of the inspectors would be, we decided to make his bonus in proportion to the number of inspectors that earned theirs. The inspectors at once began to earn bonus with great regularity, for the boss weaver found that the inspectors were only too anxious to point out defects which it was to his interest to have corrected. He visits the inspecting room frequently during each day, and by the reports he gets keeps closely in touch with what his weavers are doing. The result is a continuous improvement in the quality of their work.

304. Beside efficiency in work, moral qualities are worthy of reward. Suppose, for example, that a vacancy exists in an assistant foremanship. Naturally an efficient workman would be selected, but we should want one who had also been regular in attendance, who was truthful and honest, who had been amenable to Discipline, and who had minor executive ability.

Other qualities might be wanted also according to the nature of the case. Those records of workers which have been mentioned in Articles 43, 47, and 138 then enable a selection to be made on the basis of exact knowledge. When this method is followed, promotion automatically becomes an efficiency reward for those moral qualities which are not directly rewarded by bonus on a percentage of efficiency.

305. The old man who has shown fidelity over long years of service is entitled to an efficiency reward, it may be even to the extent of making him entirely a pensioner. One is reluctant to put anything like this on a business basis; but it might as well be recognized that it pays. Every superannuated employee in an easy job is a living object lesson to the younger men, that they too, if they stick by the firm, will be taken care of; and is one of the best of inducements to them to be patient even when things do not seem to be exactly right, and to stick by their jobs and give the firm a chance to work out its schemes, even if they do not fully understand them.

306. Opposition to efficiency work does not usually come from the direct workers; nevertheless, the means of avoiding it should be understood. It is therefore desirable to enquire into the causes that may lead them to oppose.

Kimball gives the following causes for opposition by the workers:

First, because the great majority of men are naturally afraid of all new things that they do not understand and the effects of which they cannot clearly foresee. It is very evident to the workers that time and motion study puts into the hands of the employer a much more powerful selective agency than he has hitherto possessed, and the worker is justly afraid of these scientific methods in the hands of the unscien-

tific, the unscrupulous, and the ignorant employer. If this selective power is used solely for the purpose of sorting men so as to eliminate the indolent and those who are clearly unfitted for the work in hand, there can be no objections raised against it from the humane standpoint. If, however, it is used to eliminate all but the very best workers, the effect will be disastrous both from the humane and from the economic standpoint, until an entire readjustment of the field has taken place. What is needed is a scheme whereby every man can be worked up to his full efficiency, whether or not his output be as great as that of his neighbor.

Secondly, the worker may object to these new methods because of his inherent inertia. The workman who has once learned and long practiced certain methods of doing work is seldom willing to admit that better ways may be devised if these ways appear to be radically different from those to which he is accustomed.

And lastly, he naturally opposes these new methods because his own experience and his inherited point of view naturally lead him to suspect any new methods that promise increased remuneration for increased efforts.

The first two objections may, perhaps, be removed by educational methods, but the third is deep rooted and involves principles that even the advocates of the new methods have not always fully appreciated. The basis of this objection is distrust and the root of distrust is most usually selfishness, sometimes on the part of the employee, but more often on the part of the employer; and this can be removed only when employer and employee can agree as to what is a just and equitable division of the profits of industry; and this involves, not the application of scientific methods to human relations, but the application of the Fair Deal on the part of all concerned.

307. As to the application of Kimball's suggestion of educational methods for the removal of his first two objections, Knoeppel suggests the following concrete measures:

In the first place some notification should be made to the men describing the plan as follows:

(1) Getting all the men together and addressing them.

(2) Calling a meeting of the best element in the shop and

carefully explaining the plan, furnishing them with data so that they in turn can explain it to their fellow workers.

(3) Inserting in the pay envelopes of the men a little booklet describing the proposed methods. How to figure the bonus, the matter of allowances, and other essential points can be condensed to make a four-page booklet, which will assist materially in getting the men to understand the methods.

The men should be made to feel that they will have a voice in the matter—that no one will be forced to attain 100 per cent efficiency. The fact that bonus will be paid for all saved time should be pointed out.

They should further be told that day wages will be paid whether men earn bonus or not. It will also be well to advise them regarding the steps that have been taken by the management in improving planning, in standardization of the conditions and operations, all of which will enable the men to get some idea of the expense of introduction, which will assist in enlisting their support.

If men refuse bonus, as some of them might, place it in the bank to their credit. They will take it later. If they don't, their wives will.

Two points in connection with Knoeppel's scheme of a preliminary educational campaign are important enough for special mention.

The first of these is to make it clear to the workers not only that they will benefit by the proposed methods, but that the employer will also. As long as they do not see how he is to profit, they look upon the scheme as some sort of a trap in which they are to be caught by misrepresentation, to their ultimate damage and the benefit of the employer. When it is made clear to them that both sides profit together, and that the benefits to each are dependent upon those to the other, they begin to accept the employer's statements and to feel a common interest with him in the matter.

The second point is to make clear that, in working at higher efficiencies, they will not be killing their jobs.

It is one of the most obvious things on earth to the direct workers that, if they do their work in less time, fewer of them will be needed to do it; and on this account many of them will fear that the effect, as far as they personally are concerned, will be to deprive them of their jobs. It is necessary to make it clear to them that higher efficiency means lower costs; that, if costs are lowered, the goods can be sold cheaper; and that, at the lower prices, enough more goods can be sold to keep them all in work.

308. It is obvious that it would be of vast economic value, if every one could be assigned to the work for which he is most fit. It is equally obvious that if employers generally should suddenly exercise their selective power in a negative way only, that is, to separate the unfit from their jobs, very great and widespread suffering would ensue and that, in view of the inability of the workers (see Article 267) by their own efforts to secure the tasks for which they are fit, this disastrous upheaval would bring us very little nearer to the solution than we were before.

Of course, as the work is done in one plant after another, there is time enough for adjustment to take place without general suffering; nevertheless, if the individual employer practices in his own plant nothing but the elimination of the unfit, he will cause local suffering and will greatly increase the opposition of his own employees and of workers generally to all efforts to increase efficiency.

Fortunately there are very few people who are not fairly well fitted to do something; and usually if a worker proves inefficient at one job, another to which he is better adapted can be found for him in the same plant. As noted in Articles 47 and 48, one of the

features of betterment is that the employment supervisor and the executives shall co-operate to place every worker as soon as possible in a position for which he is naturally suited.

It is only by such action by individual employers that Kimball's scheme, "whereby every man can be worked up to his full efficiency whether or not his output be as great as that of his neighbor," can be brought within the range of present reality; but by such action it can be realized in every plant to the limit of the local opportunities.

309. A preliminary educational campaign, as suggested by Kimball and Knoeppel, amounts to an appeal to reason. Unhappily, where passions have been aroused, the reason is not accessible to any appeal. Here that "distrust" noted by Kimball is so strong that no appeal is accepted as made in good faith. In that case a prerequisite to success is the persistent practice of the Fair Deal, until passions have died down enough so that a basis of common understanding can be reached.

On this point Gantt says:

> If the men know that the employer will stand by his word, and not change the time for performing a task when it has been once set, they get confidence in him, and the problem of increasing the efficiency of the plant becomes easy.
>
> In attempting to increase the efficiency of a plant, then, the first problem is to convince the workman of our good faith and that they will be treated fairly. When this has been done, we always have their co-operation to a degree entirely unsuspected by those who have never tried that method.

An example of the practical application of these principles is given in Article 8.

310. The time to put the direct workers, or any of them, on standard time and bonus is one of the most

critical points of betterment work, and must be carefully watched; and in every case must be decided according to the local circumstances.

Articles 99 to 104 will show that Planning and Despatching and Records must be developed about to the point described by those articles before the mechanism for the determination of efficiency and the payment of bonus is in existence.

Bonus payments on efficiency based on standard time should begin at such a time afterward that the workers who are offered the bonus can begin to earn small sums almost immediately, and before long can begin to earn substantial additions to their time rates.

Occasionally the principal inefficiency is idling by the direct workers; in that case they can earn bonus on proper standards from the outset, and it may be offered as soon as Planning and Despatching and Records are sufficiently developed to take care of it.

Where there are other substantial obstacles to efficiency, the workers may be unable to earn bonus on proper standards until these obstacles have been removed, and bonus should therefore not be offered to them before these betterments have been effected.

Occasional exceptional conditions may justify the use of a few temporary standards, as noted in Article 200.

It is difficult to keep up the workers' interest through a long struggle toward higher efficiency, during which they do not earn any bonus. Even the payment of small amounts of bonus is not long effective. When a man finds a few cents of bonus in his pay envelope,

the event is apt to be the occasion for general derision. The incentive, which is mostly hope thus far, will not long be effective against that, unless the amount of bonus steadily increases until it reaches a respectable amount.

On the other hand, as Planning and Despatching are developed, Conditions are Adapted, and the men are Instructed in Correct Methods; in fact as general progress is made in the application of all the Principles of Efficiency, all these things make possible the performance of the work in less time; and unless the men are offered an efficiency reward for co-operating and making good use of the opportunities thus offered them, they may simply absorb these opportunities in loitering. If they continue in this way, loitering becomes a fixed habit, and is correspondingly difficult to eradicate. Therefore the starting of bonus must not be unduly delayed.

Evidently in deciding the proper time at which to start bonus, the efficiency engineer has to hit a pretty small target. Fortunately one can miss the exact bull's eye without causing absolute failure. Mistakes can be corrected by care and patience; but the nearer one can come to the exact psychic moment in starting bonus, the better things will go.

311. It has been stated in Article 102, that the despatcher should enter the standard time for the job on the service card, before the card goes to the worker. For convenience in figuring the efficiency, this entry should be made in decimals of hours.

As a statement of work to be done however, a standard expressed as so many pieces per hour is much easier to understand. In this connection, Knoeppel makes the following recommendation:

It is an excellent plan to give the workmen, in addition to any instructions that may be prescribed, an outline of productions required at varying efficiencies. A standard expressed in terms of pieces per hour sometimes scares a workman. He feels it to be an impossible task and as a result is discouraged even before he tries. The facts can be presented as follows:

Operation .... Part No. .... Schedule ....

PIECES PER HOUR	EFFICIENCY PER CENT	BONUS IN CENTS
45	60	0
50	67	1 per dollar wage
60	80	5 " " "
68	90	10 " " "
75	100	25 " " "
83	110	35 " " "

As can be seen, the operator first sees the 45 pieces per hour. He knows he can do this. He sees the 50 and 60 and feels that by a little extra effort he can turn out the required amount. He feels that 68 would be hard, 75 difficult, with 83 out of the question, but he knows that he can do enough to qualify as a bonus earner to begin with, and this is an important consideration with many workmen. As he becomes more familiar with the plan and the work, he is not so afraid of the standards as he was to begin with.

Such a tabulated statement as Knoeppel suggests is conveniently issued to the worker with the service card. This should be regarded as a temporary measure only. As soon as the worker has found that he can average a good efficiency and earn bonus regularly, the special statement of the standard can be discontinued.

312. For reasons which are indicated in Articles 198, 208 and 209, the standard times, as originally installed, will tend to be too short. Immediately after workers are started on standard time and bonus, their efficiencies should be watched. If they do not earn

bonus soon and if their efficiencies do not improve continuously until they regularly average about 100 per cent, the causes of this failure should be investigated; and if it is found that the standard time is too short, it should be corrected promptly. The workers should also be encouraged to complain of any standards that they consider unreasonable. They will probably hesitate about doing this at first; but if they see that the efficiency staff, independently of them, is trying to find and correct standards that are too severe, they will be encouraged to express their own opinions. A standard should not be made easier on a worker's complaint without a restudy. If the standard is found to be too severe, the relief should be prompt. If it is decided to keep the standard in force, the reasons for doing so should be explained. For example, it may be found that some unadapted condition has escaped observation; and that by the correction of this the standard time will be made reasonable. If so, the fact should be explained to the worker and the condition should be adapted as promptly as possible.

Naturally the workers' fear is that standard times will be shortened. If instead they see that none are shortened but that those that are too severe are lengthened, the effect is excellent and goes far toward winning the necessary confidence of the workers.

313. In order that the full moral effect of bonus may be produced, it is necessary that the workers should think of it as a separate and distinct thing from wages. To this end, it is common practice to pay the bonus on a different day from wages, or to accompany the payment of bonus with a separate little voucher check or memorandum, stating the amount of bonus and perhaps also the efficiency.

314. Bonus to the direct workers is instituted primarily to stimulate individual efficiency. It not only does this but also promotes team work. The reason for this paradoxical result is that, under the division of labor existing in industry, every worker is dependent upon others so that, if one man fails to work efficiently, he hinders others as well. The pressure upon every man from his shopmates to keep up his end therefore becomes so great that inefficient men have not the moral stamina to resist, and either become efficient or get out.

315. While efficiency reward is essential to full results, we should remember the limitations of this principle, which, in the minds of many business men and managers, seems to have usurped the whole field of efficient management, as they evidently think that by paying bonus or by working on piece rates, they have solved the whole problem of efficiency.

On the contrary all that efficiency reward can do is to encourage a man to take an intelligent interest in his task, to work faithfully at it, and to give the employer his good will. These are very important, but are not the only problems of management. For instance, nothing that the individual can do can fully make up for the lack of adequate planning and despatching. I have seen workers on piece rates chafing in idleness and without pay because the management could not, or did not, get work to them which was in the plant and for which they were eager. Only the application by the management of all the principles of efficiency can produce a perfect result.

Chapter XV

DETERMINATION OF EFFICIENCIES

316.

ONE must know not only where the inefficiencies are and how to correct them, but where to begin and how to direct the work, so as to get financial results at the greatest possible speed.

Compared to European practice, the efficiency of the American factory power plant is usually very low. On the other hand, the cost of power to an American factory is usually so small a part of the total operating cost, that no great percentage of saving would be shown, even if free power were obtained. In other parts of a plant low efficiencies may also be found, whose improvement would not be of appreciable financial value.

317. Usually it is a condition of successful betterment that financial savings should be shown without long delay and without great cost to secure them; at least that the work should soon begin to pay for itself. Hence it is usually necessary to undertake at first some line of work which will begin very soon to show an appreciable saving in money.

318. Supposing the total cost of operating a department for one year to be $100 000, and its efficiency to be 70 per cent, then the cost is divisible as follows:

Standard cost	$70 000.00
Inefficiency	30 000.00
Total cost	$100 000.00

The inefficiency of $30 000 is a preventable loss and by raising the efficiency to 100 per cent, the cost can be brought down to $70 000.

Hence there are two factors in the determination of feasible saving—actual cost, and efficiency.

319. Work in any one department, or even on any one operation, is never limited in its effects to the direct point of application, but produces results which spread through the whole business. Conversely, the efficiency of the department in which work is undertaken is affected by the efficiency of other departments, especially of those which come before it in the manufacturing process.

320. For the reasons above stated, it is necessary to approximate actual costs and efficiencies throughout the business, before deciding on the point at which to begin work.

321. This chapter deals with the determination of efficiency; that of the other factor, actual cost, is considered in Chapter XVI on Cost Finding.

322. Any element of cost is the sum of three terms:

Cost of direct labor, or labor applied directly to the element in question;

Cost of direct materials, or materials applied directly to the element in question; and

Its proper share of the burden or overhead expense, due to the business in general, but not traceable directly to any item of product.

323. Hence we have also three efficiencies to determine:

Efficiency of direct labor;
Efficiency of direct materials; and
Efficiency of overhead expense

324. Any one of these three efficiencies is the product of four factors:

Efficiency of use;
Efficiency of supply;
Efficiency of price; and
Efficiency of distribution.

325. These four factors of efficiency are defined as follows:

Efficiency of Use is the quotient obtained by dividing actual result obtained by the use of anything, by what ought to have been obtained—that is, by the standard result. If a workman in one hour produces seventy pieces when the standard result is one hundred, the efficiency of use of his labor is seventy per cent. It is more convenient usually to express this efficiency for labor in terms of standard and of actual time. In the example given, the standard time for producing one hundred pieces would be one hour, while the actual time required would be 1.43 hours. The efficiency would then be standard time divided by actual time, or 1. ÷ 1.43=70 per cent.

Efficiency of Supply is the quotient obtained by dividing the amount of anything which would be necessary for any purpose (that is the standard amount) by the amount actually so provided. If one hundred men are employed, where only ninety-five are needed, the efficiency of supply of labor is 95÷100=95 per cent.

Efficiency of Price is the quotient obtained by dividing what ought to be paid for anything (that is the standard price) by what is actually paid for it. If the

average rate of wages in a plant is 19 cents per hour, when the local market rate for that class of labor is 22 cents per hour, the efficiency of price of labor is $22 \div 19 = 116$ per cent. An efficiency of price of labor above 100 per cent is often found, and is invariably a cause of inefficiency of labor because it results in filling the plant with the culls of the local labor market, thereby running down both efficiency of use and efficiency of supply to such an extent that the product of the four factors is, on the whole, decreased.

Efficiency of Distribution is the quotient obtained by dividing the price of what ought to be used to produce a given result (that is the standard price) by the price of what is actually used. If a mechanic receiving 35 cents an hour is used to do work that ought to be done by a machine operator at 22 cents per hour, the efficiency of distribution of labor is 63 per cent.

326. Suppose that the four factors of efficiency have the values given in the above examples. Then the efficiency of labor is the product of the four; that is

$$.7 \times 95 \times 1.16 \times .63 = 48.5 \text{ per cent.}$$

327. Usually it is most convenient to determine the efficiency of use of labor by time studies. It is not necessary to make a large number of studies for this purpose, provided the subjects of the studies are properly selected. My own practice is to ask the foreman of every department to select for time study a few workers whom he considers to be about the average of his department. A time study is then made of each of these workers, and standard and actual time is determined from every study. Standard time divided by actual time gives the efficiency of use of labor in every case, and the average of these results gives the efficiency of use of labor in the department. Where

the subjects of study are selected as above stated, I have found the error of sampling, though appreciable, to be negligible for the purpose in hand.

328. The efficiency of supply of labor can be approximated closely enough in the course of a few days, by walking through the plant at various times during working hours, counting the number of workers who are idle at the moment of passing them, and comparing this with the number of workers present. In determining the result, allowance must be made for the amount of rest during working hours, which is necessary to obtain the maximum of efficiency of labor as the final product. See Article 208.

Suppose that, on an ordinary class of work, out of one hundred male workers present, twelve are observed to be idle at the moment when the observer passes. Since 10 per cent should be resting at any moment, and thus only ninety men should be at work, the efficiency of supply of labor is $88 \div 90 = 98$ per cent.

329. The efficiency of price of labor can be obtained by comparing the pay-roll of the plant with the local market rates of wages for workers of the same class. In so doing the effect of the application of the principle of Efficiency Reward must be considered, because maximum savings will not be effected unless the workers are given a share of them by the application of this principle. For example, let the average hourly wage rate of the workers be 20 cents, while the average market rate for their class of labor is 22 cents. We shall have to count, not only on paying them 22 cents per hour, but on paying them an efficiency reward as well. This is more fully discussed in Chapter XIV; but may here be assumed with sufficient accuracy at 20 per cent of the hourly rate. Efficiency re-

ward will then cost 4.4 cents per hour, making the total average standard cost of labor per hour, 26.4 cents. The existing efficiency of price of labor would then be average standard cost divided by average actual cost, $26.4 \div 20 = 132$ per cent.

330. Efficiency of distribution of labor can be determined by time-motion studies; an example of such a study and of determinations from it is given in Table 6 and in Article 166. Usually it would take more time than is desirable to spend on preliminaries, to make an approximate determination of this factor of the efficiency of labor, and it is therefore usually best at this stage to assume that it is 100 per cent. This makes the estimate of feasible saving on labor conservative, as it is better that all preliminary estimates should be.

331. A time study is an analysis of the use of a sample of time, in which the total time is separated into certain parts, the percentage of each of these elements used or wasted is determined, and causes, if possible, are determined for such losses as are detected. It is evidently possible to analyze the use of sample lots of materials in the same way, and to obtain corresponding results, from which may be determined the efficiency of use of materials. There is this difference, that while a skilled time-study man can usually (though of course not always) estimate approximately the efficiency of the use of labor without the aid of any one skilled in the particular process which is under investigation, such aid is apt to be needed to estimate the percentage of material scrap that should have been saved.

This kind of an analytical study of the use of materials has not attracted much attention in the literature

of efficiency, but it is important. Especially where large quantities of valuable raw materials are cut up as the first stage of a manufacturing process, there is apt to be considerable waste, of which an appreciable part can be saved by comparatively simple methods. This is discussed in detail in Article 302.

A paper by E. C. Church before the National Association of Cotton Manufacturers states the ways in which the values of the other three factors of the efficiency of material are commonly lowered in practice, and therefore indicates the points which may require attention in a preliminary investigation.

With headings supplied according to the definitions of Article 325, Church's statements are as follows:

EFFICIENCY OF SUPPLY

In the first place much unnecessary material is bought. While a purchasing agent is haggling over some slight difference in price he may be unaware that the supplies he is bargaining for are quite unnecessary, in fact that there are already plenty on hand. This will often happen where improper storeroom methods and the absence of the necessary records fail to reveal the conditions.

Many requisitions are excessive in amount. The purchaser may not realize that carelessness in the estimating department has resulted in ordering an excess of material. Buying even a little extra material which is not needed and will not be used, may offset the most painstaking price shaving ten to one.

EFFICIENCY OF PRICE

Market conditions are often ignored. Perhaps when supplies are bought they are bought as cheaply as possible, yet it frequently happens that lack of forethought makes it necessary to go into the market when conditions are unfavorable and prices high—just because no proper attempt had been made to estimate the future requirements of the business and plan a purchasing campaign to extend over a considerable period of time and thus take full advantage of the various

fluctuations and changes in trade conditions. What is a low price, if forced to purchase at once might really be a high price when compared to the figure that might have been obtained if the necessity for making the purchase could have been foreseen.

The best purchasing economies are rendered of no avail by a careless inspection of the goods actually delivered. An infinitesimal difference in price between competitors is instantly apparent on the bid sheet, but vital differences in the value of their respective deliveries might remain undiscovered unless there be a careful and systematic inspection of all goods bought. Superficial examination and a mere counting and weighing will not suffice.

EFFICIENCY OF DISTRIBUTION

Again, too expensive supplies are often ordered. Perhaps while all the attention of the agent is being given to this small difference of price it may be that the man ordering the supplies in question specified qualities and grades superior to the requirements of the work to be done. Without standard specifications based on the actual conditions to be met it is easy to buy materials that cost double what is necessary.

Frequently supplies are not put to the use for which they were intended. High grade materials are invariably issued by careless men in charge of supplies if the cheaper article called for is not in stock or convenient to get at. The difference in price between the material actually used and the material that would have served the purpose is a clear loss.

332. The efficiency of some overhead expense, power for example, can be determined approximately by scientific tests. At the other extreme, the efficiency of other overhead, like depreciation, is very elusive by any method of determination. However, the salient fact about the overhead is that it remains nearly constant regardless of production, while for any given number of workers production will vary directly with the product of the efficiency of supply and the efficiency of use of labor. Therefore to the extent that feasible increase of efficiency of supply and use of labor can

be utilized to increase production, a reduction of overhead per unit of product can be counted on, almost in the inverse ratio of the product of these efficiencies. If the market will not absorb any increase of production, practically no saving in overhead can be counted on. Of course the investigator may in a particular case detect the possibility of savings in overhead expense, and in the course of the actual work of betterment some such will probably be discovered. It is usually necessary to count on an increase in the overhead expense due to supervision. Probably some clerks, time-study men, and planners will be needed to operate permanently the efficiency measures which are expected to be installed; and the annual pay roll for these should be estimated as an additional expense of supervision. Very often, also, foremen ought to be relieved of clerical work, and adequate inspection force ought to be provided, all of which means additional expense of supervision.

Chapter XVI

COST FINDING

333.

IT was pointed out in Chapter XV that, in order to begin work where appreciable money savings would result as quickly as possible, it is necessary to know not only efficiencies but also actual costs. It is therefore advantageous to determine costs as a part of the preliminary work.

334. Cost finding moreover is important not only as a preliminary, but continuously throughout all management. It is therefore necessary to treat it more broadly than would be necessary for the mere purpose of a preliminary determination of where and how the money is being spent.

335. Let us apply to our own work the principles of efficiency and inquire what are the Ideals in cost finding. Evidently they are as follows:—

For the factory executive:—

To make known approximate costs immediately, rather than exact costs after long delay.

For the accountant:—

To enable the daily collection from the factory of a sufficient amount of burden on regularly recurring direct expenses, to balance as nearly as possible the overhead expenses which occur more or less irregularly.

For the sales manager:—

To make known the approximate cost of the finished article in order that selling may be directed intelligently.

For the purchasing agent:—

To make known the approximate effect on the cost of the finished article, of variations in the cost of supplies and of periods of storage, in order that advantage may be taken of the condition of the market in buying supplies.

For the general management:—

To make the financial condition of the business known up-to-the-minute and at all times, as a guide to the policy of the concern.

336. Fortunately these Ideals are not conflicting. While the first and last call for promptness, none calls for other than approximate accuracy. A prerequisite of promptness is simplicity. Hence the required characteristics of any system of cost finding are approximate accuracy and as much simplicity as is consistent therewith.

337. Promptness is especially important to the factory executive. If an order for one thousand pieces is going through the shop on which the standard cost of one operation is $1.00 per hundred, and he knows by the time the first hundred are completed that the actual cost is about $1.11, he has a chance to prevent the loss of $.99 on the remaining nine hundred; but if he does not know the cost until the whole thousand has gone through, even though he may then know that it was exactly $1.095, the information is too late to be of any practical value.

338. For the factory executives the ultimate purpose of all cost finding is the operation of the plant on

Standard Cost. Moreover this is essential to all schemes of cost finding, because they are all based on the assumption that past cost equals present cost; and unless costs are made to approximate predetermined standards, there is no assurance that this is correct. In order to accomplish the desired results, approximate cost finding for the shop must be tied into the daily routine of its management in a manner which is explained in Articles 96, 102, 113, 114 and 129.

339. In an industrial plant it may be necessary that the distribution of overhead expense on a theoretical basis should be readjusted in order to enable the business to meet competition. For example, one department may be handicapped by worn-out equipment which requires a large expense for maintenance. Such a condition probably ought to be terminated either by discontinuing the department or by equipping it properly; but as long as it is allowed to continue, the charge to the department for maintenance of its equipment should be only such as would be required with good equipment, and the balance of the maintenance expense should be distributed to all the departments as part of the general indirect expense. If this is not done, the product of the department may have to be sold at a book loss.

Such a redistribution of indirect expense must be made mostly by judgment and common sense; but the following general principles may be of service.

Indirect expense which tends to increase the value of a certain product should be charged to that product only, and should be added to its selling price, instead of being distributed as a general indirect expense; for example: A certain hotel is built about an interior hollow square. This square is a court in which an

orchestra plays during dinner. The orchestra adds directly to the attractiveness of the dinner and of the interior rooms, whose windows look out onto the court, and this is substantially its only value to the business. The cost of the orchestra should be considered as a burden on the dinners served and on the interior rooms, and on them only, and its cost should be distributed as an addition to the prices charged for them.

Indirect expense which is merely accidentally connected with any product and which does not add to its value, should be distributed generally instead of being made a burden on that particular product. For example, the buildings of an industrial plant which look out on any important thoroughfare are usually more ornate and expensive than those in the interior of the plant. The rent of the departments which happen to be housed in these buildings should not be increased on this account, but the expense due to the ornamentation of these buildings should be uniformly distributed as rent among all the departments.

Errors of judgment and accidents should be paid for by distribution as part of the general indirect expense. For example, if a large and expensive machine is bought and it is found practicable to operate it only a few hours a year, the whole actual rate on this machine should not be concentrated on the small amount of product which passes through it; but this product should be charged only with such a machine rate as would have existed if a suitable machine had been installed, and the balance of the actual rate should be distributed to the general indirect expense.

If a trolley car meets with an accident which causes heavy expense for repairs, that expense is not collected from the passengers who happen to be aboard at the

time; but it is distributed to the system as a whole, and a part of all fares collected is used to pay for it.

Departments which are exceptionally favorably situated may be made to help the business as a whole by being saddled with more than their proportionate share of the indirect expense. For example: if any particular product is manufactured by patented machines which put them beyond competition by other makers who are unable to use these machines, this product may be arbitrarily burdened with as much overhead expense as it can bear and still hold the market at a reasonable profit in order to enable the rest of the product to meet competition more favorably.

Conversely, departments which are very unfavorably situated may be relieved of part of their proportionate share of indirect expense, the amount of which they are relieved being distributed to the rest of the business.

Care must be taken that such redistribution is not abused into causing the business to continue the manufacture of a product on which it actually loses money or into causing it to fail to sell an article which it really can manufacture at a profit. We have here a case of that conflict of requirements which is familiar to every engineer in every part of his work. As in all conflicts of requirements, a working result can be reached only by a compromise guided by judgment and common sense.

340. The details of cost finding are important to the person who actually does the efficiency work but may not interest the busy manager who delegates such details to others. A general manager may therefore find it convenient to pass at once to Article 375.

341. It is convenient to use a diagram in the form of Figure 7. It is shown in skeleton form only, as that is sufficient for explanatory purposes.

342. Direct materials, direct labor, and direct use of equipment are those of which the cost can be directly attributed to any particular job, and which can therefore be charged directly to that job as part of its cost.

343. All other materials, labor and use of equipment are indirect, cannot be charged to any particular job, and their cost, commonly distinguished by the name of "overhead expense," is provided for in burdens on direct materials, direct labor and direct use of equipment.

344. All costs are therefore expressed by the equation:—

$$\text{Total cost} = M(U + u) + H(W + w) + h(E + e) \qquad (1)$$

where M equals quantity of direct materials,
U equals unit price of direct materials,
u equals burden on direct materials,
H equals man-hours of direct labor,
W equals wage per man-hour,
w equals burden on direct labor,
h equals machine hours of direct use of equipment,
E equals direct machine, or more properly, equipment rate, or hourly cost of running direct equipment, and
e equals burden on direct equipment.

The Cost Finding Diagram, Figure 7, is based on Equation (1).

345. In the preparation of the diagram, the accounts are first listed in the top, or first line, and are given letter designations for convenient reference.

346. Following the classification shown by the equation all costs are divided, in the next to the top, or

second, line of the diagram, into the three blocks headed respectively

Materials,
Labor, and
Equipment.

347. The totals of the various accounts are shown at the top of the diagram. For example, in the second line, "Materials Account, Supplies for Maintenance of Machinery," is account "i. Supplies for Maint. Mach." of the list of accounts in the first line.

By reference in Figure 7 to the block "Equipment" in the second line and to the block "hE," Cost of Direct Use of Equipment, in the third line, it is seen that in the last the only direct cost of equipment is the account x + y, "Direct Equipment Charges of Direct Departments," and by reference to the block "Equipment" of the second line and to accounts x + y of the first line, it will be seen that this consists of 10 per cent depreciation and 6 per cent interest on the appraised value of the equipment which is directly used.

348. Depreciation is impossible to estimate exactly, but the allowance for it should at least be large enough. A uniform allowance of 10 per cent on appraised value is commonly accepted as sufficient; but it is preferable that real depreciation should be more closely approximated. This is feasible by the application of the principle of Records, which is explained in Article 139.

Interest on all appraised values is, of course, indisputable.

349. As a check, the totals of each line of blocks, except the fourth, are added up at the right, and must be the same in every line.

350. The third line of blocks subdivides the three blocks of the second line for convenience of future reference, but the fourth line of blocks is filled out directly from the second, and without necessary reference to the third.

351. In the third line of blocks, all costs are divided into the direct classes,

Direct materials, *M U*,
Direct Labor, *H W*, and
Direct use of equipment, *h E*;

and all indirect costs, or "Overhead Expense," are classified as

Power (including light and heat)
Maintenance,
Supervision,
Rent, and
Miscellaneous.

352. In the practical classification into direct and indirect in this line, some variations from the definition above given may be allowed as a matter of practical experience, or to economize clerical labor. For example: nearly all the work of an overhead traveling crane is direct; but, on account of the short time that the crane works on any one job and its continual moving about, it would be prohibitorily expensive to keep accurate account of the use of the crane directly on jobs, or even to keep a list of the direct jobs on which it works. So it is customary and preferable to put all the cost of the crane into the overhead expense.

353. The few costs which do not fall under any of the other classes are placed under Miscellaneous. For example, Account *a* under Miscellaneous, comes from "Labor" in the second line and is "Employers' Lia-

bility Insurance,'' found originally in the first line as Account *a*.

354. Into the direct blocks, *MU, HW* and *hE,* of the third line are brought down simply the direct costs shown by the accounts at the head of each list in the blocks of the second line; for example, in the block *MU* is shown the sum of two accounts *b* and *c* of ''Direct materials'' which appear at the head of the Materials list in the second line. It is easy to keep account of the direct costs and to charge them to jobs to which they are incident, with the exceptions similar to that noted in the ease of the traveling crane, Article 352. The accounts themselves should therefore show these direct costs.

355. Into each of the indirect blocks, ''Power,'' ''Maintenance,'' ''Supervision,'' ''Rent'' and ''Miscellaneous,'' in the third line are classified such accounts from ''Materials,'' ''Labor'' and ''Equipment'' in the second line, as belong to it. For example, ''Power'' brings down from ''Materials,'' account *k* for ''Light, Heat and Power,'' purchased from outside supply companies, this account having been originally listed as that of a purchased material; ''Maintenance'' brings down from ''Labor'' account *r,* ''Labor for the Maintenance of Machinery''; ''Supervision'' brings down from ''Equipment'' accounts *l* and *m,* ''Supervision of Direct and Indirect Equipment,'' respectively; and ''Rent'' brings down from ''Labor'' account *q,* ''Labor for Maintenance of Buildings.''

356. The fourth line carries out an investigation of the redistribution of the indirect charges through one another. This can be best illustrated by the diagram, Figure 8, which shows in graphic form the same facts as are shown in tabulated form in the Power block of

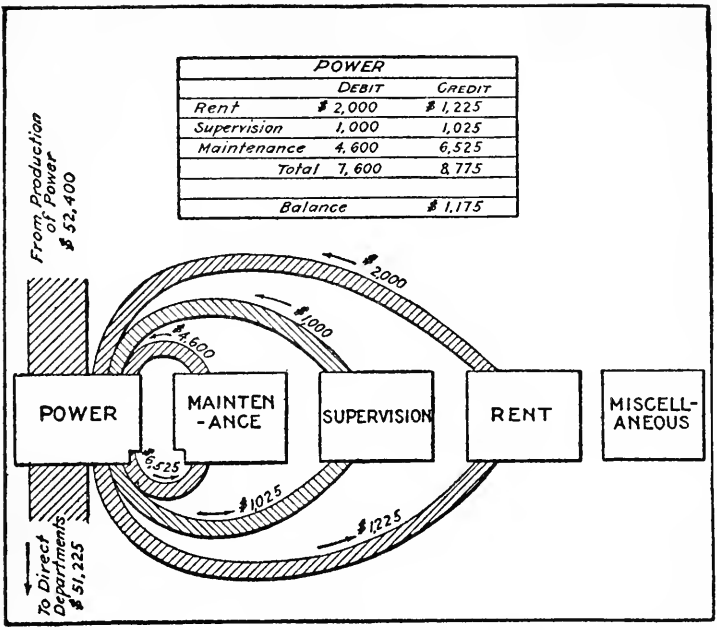

FIG. 8. GRAPHIC DIAGRAM OF COST RELATIONS

the fourth line of the Cost Finding Diagram. Though power itself is an item of indirect expense, we may classify this expense as direct-power expense and indirect-power expense, in accordance with the definition of direct and indirect costs above given; that is, direct-power expense is expense that can be directly attributed to the generation or purchase of power (in this particular diagram, power includes light and heat) and which can therefore be charged directly to power as part of its cost; all other expense for power, for example power's share of the general administration of the business, which is part of a direct-supervision expense, are indirect-power expenses.

The total annual direct-power expense is $52 400. Of this a portion is distributed to all the other indirect departments. For example: light, heat and power to the general offices goes from power *i* into "Supervision" and becomes an indirect-supervision expense. The total of expense thus transferred from Power to Supervision is shown by Figure 8 as $1 025.

Similarly there are indirect-maintenance expenses and indirect-rent expenses for "Power," all of these being of total amounts shown by the Credit side of the "Power" block of the fourth line of the Cost Finding Diagram and by Figure 8. There happens in this case to be no exchange of expense between Power and Miscellaneous.

Similarly there are indirect-power expenses for "Maintenance," "Supervision" and "Rent." Above is given an example of an indirect-power expense for "Supervision." The amounts of all these indirect-power expenses are shown both by the Debit side of the "Power" block of the fourth line of the Cost Finding Diagram and by Figure 8.

As shown this interchange of indirect expenses gives power a credit balance of $1 175 and the net "Power" expense is therefore $52 400 — $1 175 = $51 225.

It is theoretically necessary to make this investigation, because the indirect expenses are not all distributed to the different departments in the same ratio. For example: a department using a large amount of power may be housed in a cheap, small building. It should therefore be charged with a large part of the expense for power and with only a small part of the expense for rent. Therefore that part of the direct-power expense which is distributed to "Rent" as an indirect-rent expense should be dis-

tributed to this department in a much smaller proportion than should the corrected expense for power.

Similar considerations apply to the redistribution of the expenses for "Maintenance," "Supervision," "Rent" and "Miscellaneous"; and this redistribution is carried out in the fourth line of blocks of the Cost Finding Diagram, Figure 7.

357. If it could be foretold that any block of indirect expense of the third line would be no more affected than power here is, by the redistribution of the fourth line, this redistribution could be omitted with practical accuracy; but this is merely a working approximation for which there is no theoretical justification.

358. The quantitative distribution of expense is a matter of much difficulty, and must be accomplished rather by good judgment than by strict adherence to any theory. First, such information as is possible should be derived directly from the accounts. Second, any expense should be distributed to any classification as a first approximation, as nearly as possible in proportion to its actual use of that expense. Finally, the details must be readjusted in accord with good judgment and common sense. See Article 339.

359. As an aid in the distribution of "Power" in proportion to its actual use, the lower part of the "Power" block of the fourth line gives a distribution of horse-power-hours into steam, electric, gas and hydraulic.

360. The fifth line of the diagram shows the distribution of direct and indirect costs to direct materials and to the several direct departments.

361. *"MU,"* direct materials, will be shown for any job by the "Material Service Card" discussed in Article 114, and the overhead *"Mu"* on direct materials

will be uniformly distributed over all materials, so it is unnecessary to distribute "*Mu*" to departments.

This uniform distribution of the overhead "*Mu*" to all materials is in direct proportion to their purchase price. In the block "*Mu*" in the fifth line, it will be seen that the final burden on direct materials is 3.2 per cent, that is, material whose purchase price was $1.00 will be charged to the job by the Cost Department at $1.032.

This method of charging is evidently only a convenient working approximation, since heavy, bulky materials of small unit value would usually cost more for handling and storage in proportion to their value, than would small light materials of large unit value. Where the burden on direct materials is so small as in this case, the error in any case evidently can not be large; but if this burden were larger it might be necessary to distribute it more accurately.

362. Similarly the amount of direct labor (*HW*) to be charged for any job will be shown by the labor service cards discussed in Article 96; but the burden (*w*) on labor will probably not be uniform in all departments, and "*HW*" should therefore be distributed to departments at this point as a guide to the determination of the burden on labor for every department.

363. The distribution of "*hE*," direct use of equipment, should, as a first approximation, be determined as the sum of interest on investment for, and depreciation of, the direct equipment of any department. It may even be carried so far as to have a separate charge for every machine; but, as a matter of practical convenience and economy of clerical labor, it is seldom practicable to carry this to a greater refinement than a separate rate for each department.

364. The theoretical distribution of "Power" to departments should charge each with the corrected expense for the number of horse-power-hours which it uses. A practical difficulty at this point is the determination of this consumption, which is apt to resolve itself into making the best estimate possible from the information available. The more general use of meters of all kinds would doubtless pay as a means to the more accurate determination of costs and elimination of wastes.

In the distribution of Power to Labor and Equipment of the several departments in the fifth line, Labor should be charged theoretically, with light and heat, and with power for ventilation, and usually with power for the operation of hand tools, such as pneumatic hammers; while Equipment should be charged with all other power.

365. The actual fact probably is that the amount of indirect expense for supervision that is due to any department is in a proportion somewhere between a direct ratio to the total of its direct pay roll, and a direct ratio to the total number of its direct workers. A skilled worker, whose tasks require the attention of the Engineering Department for the preparation of drawings, and of the Planning Department to have everything ready for his work, certainly occasions more expense for such supervision than does an unskilled laborer. On the other hand, the superior intelligence of the skilled man may diminish the amount of disciplinary and sanitary supervision that he may require, below that of the cheaper unskilled man. For simplicity, expense for supervision ought to be distributed in proportion to direct pay roll, or in proportion to number of direct workers, whichever seems to

be more nearly correct for the case in hand, unless such distribution would evidently cause substantial error, in which case some intermediate proportion should be adopted.

The distribution of Rent is first approximated theoretically by distributing to each department a share of the yard space, as nearly as possible in proportion to its use thereof, and charging it ground rent in proportion to the space used by it; and by distributing the rent of any building to the departments housed in it, in proportion to the space which they occupy.

366. Whatever redistribution of any indirect expense may be made as suggested in Article 339, the total of indirect expense provided by the distribution must not be altered. For example: in the third line of the diagram, "hE," the cost of direct use of equipment totals $(x + y)$; and however much the amount charged against each department in the original theoretical layout of the fifth line may be altered, the total of the cost so provided for must remain the same. The necessity of this is evident from the fact that this expense actually exists in the business; and, in some way or other, it must be provided for and must be recovered in the sale of the product.

367. In the diagram, the final distribution of the total of any indirect expense allocated to labor or equipment has been made in the fifth line, to the several departments. It is usual to make these distributions in proportion to their total direct pay roll, and in proportion to the total appraised value of their direct equipment respectively. This assumes that any skilled mechanic earning 40 cents an hour causes twice as much indirect expense as any laborer earning 20 cents an hour, and that any machine appraised at

$10 000 causes twice as much indirect expense as any machine appraised at $5 000. Evidently this cannot be in exact accord with the facts, but it makes the practical cost keeping very convenient; and hence, in accord with the principle of simplicity, it may be used, unless it is known to be too far from the truth for a working approximation.

368. The blocks of indirect expense, Power, Maintenance, Supervision, Rent and Miscellaneous, of the fourth line are now brought down into the blocks of the fifth line and therein redistributed to "*MU*," direct materials, and to the several departments, being distributed in any department between labor and equipment.

369. The expenses of any direct (commonly called productive) department, for Power, Maintenance, Supervision, Rent and Miscellaneous, shown by the blocks in the fourth line to be chargeable to labor, are totalled and constitute the burden on direct labor for that department.

It will be noted that this distribution for Department 1 is by a uniform percentage of 54.5 per cent on all direct wages; that is, $1.00 direct wages on any job in that department will be charged to that job by the cost department as $1.545. This method of distribution is discussed in Article 367.

370. The expenses of any direct department for Power, Maintenance, Supervision, Rent and Miscellaneous, as shown by the blocks in the fifth line to be chargeable to equipment, are totalled and constitute the burden on equipment for that department.

It will be noted that this distribution for Department 1 is by a uniform percentage of 666 per cent on all direct machine rates. That is, any job in that de-

partment which is done on a machine whose hourly rate is $1.00, will be charged by the Cost Department with $7.66 for the use of the equipment. See Article 367.

371. If the uniform distribution of the indirect expense to labor and equipment has been altered in readjustment to meet competition, as suggested in Article 339, it is evident that the distribution to direct wages and direct equipment in the fifth line of Figure 1 would have to be made in accord with the distribution actually followed. As any non-uniform distribution would complicate the accounting and increase its expense, and would also increase the chances of clerical error in the determination of cost for any job, it is evident that the uniform distribution should be used, unless there is a good reason to the contrary.

372. In the fundamental equation, the quantities, u, w, e and E have been evaluated by the above process.

To determine the cost of any job, it remains to evaluate M, U, H, W and h.

M, the quantity of the materials directly used; H, the man-hours of direct labor used on the job; W, the average hourly wages of the men directly employed on the job; and h, the hours of direct use of every machine; must therefore be reported from the shop to the Cost Department immediately upon the conclusion of any job. U, the unit purchase price of all materials directly used, must also be immediately known to the Cost Department, and this information may come from the shop, from the Purchasing Department, from the Stores-keeping Department, or from the files of the Cost Department itself as is most convenient; but some definite and positive means of bringing it to the knowledge of the Cost Department immediately upon

the conclusion of any job must be provided and standardized.

M, H, W and h are conveniently and automatically reported to the Cost Department by means of Labor and Material Service Cards, described in Articles 96 and 114, respectively.

373. In a plant where there is very little direct labor without the simultaneous direct use of equipment, very approximately H equals h, and the fundamental equation can be written

$$M(U+u)+H(W+w+E+e)=\text{Total Cost.}$$

Then, if $B=w+E+e$

the fundamental equation can be written:

$$M(U+u)+H(W+B)=\text{Total Cost.}$$

which assembles all the labor and equipment charges other than direct wages into one burden on the last. It will then be sufficient for the Labor Service Card to report H and W for any job, B being already known in the administrative offices concerned.

374. It is well known that overhead expense continues at nearly a uniform rate per unit of time, regardless of the amount of business being done; that is, it varies directly with time. Therefore in cost finding, it must be distributed in proportion to time. It will be noted that this is done in the Cost Finding Diagram, Figure 7, except in the case of the overhead on Materials. As this is usually a small part of the total overhead, distribution according to value of direct materials is used for simplicity; but in the distribution of the important overhead on labor, the time rate should be used. For this reason, in the preparation of the diagram, it was assumed for simplicity that labor was paid on time rates. Where labor is

paid on piece rates, the labor requisitions would be required for purposes of planning and despatching, transportation, pay roll and inspection, no less than when labor is paid on time rates; and these requisitions should, in either case, be made the means of recording H, the man-hours of direct labor expended on every job. The overhead on labor should then be determined by multiplying H by w, the burden on direct labor, instead of by multiplying the piece rate earnings on the job by burden coefficient as is commonly done.

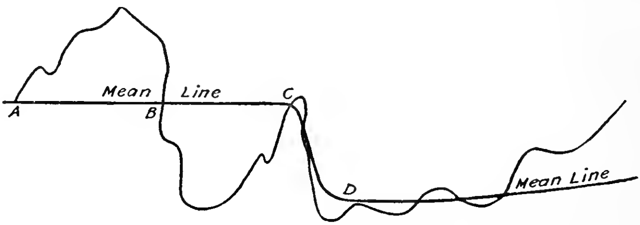

FIG. 9. GRAPHIC DIAGRAM OF BUSINESS FLUCTUATIONS

375. Business fluctuates in a series of irregular pulsations about a mean line (Figure 9). This introduces into the problem of cost finding for the accountant, the sales manager and the general manager, a complication which Gantt states thus:—

> If the factory is running at its full, or normal capacity, this item of indirect expense per unit of product is usually small. If the factory is running at only a fraction of its capacity, say one-half, and turning out only half of its normal product, there is but little change in the total amount of this indirect expense, all of which must now be distributed over half as much product as previously, each unit of product thereby being obliged to bear approximately twice as much expense as previously.
>
> When times are good and there is plenty of business, this method of accounting indicates that our costs are low; but

when times become bad and business is slack, it indicates high costs due to the increased proportion of burden each unit has to bear. During good times, when there is a demand for all the product we can make, it is usually sold at a high price and the element of cost is not such an important factor. When business is dull, however, we cannot get such a high price for our product, and the question of how low a price we can afford to sell the product at is of vital importance. Our cost systems, as generally operated at present, show under such conditions that our costs are high and, if business is very bad, they usually show us a cost far greater than the amount we can get for our goods. In other words, our present systems of cost accounting go to pieces when they are most needed.

376. The engineer's way of dealing with such fluctuations as are shown in Figure 9, is by means of a fly-wheel. Such a fly-wheel can be introduced into cost finding by figuring the overhead and the burden ratios from the accounts for at least the complete period of one cycle, as from *A* to *C*, Figure 9. The burden ratios, so determined, are the average of all conditions of the business, during both good and bad times.

Then in the routine of the Cost Department, all service cards should be figured daily to show how much overhead expense has been collected on them, and a summary should be made at the end of the month showing the total service card earnings of overhead expenses for the month.

We now have three items for consideration, viz:—

Standard Allotment,

Actual Expenses paid, and

Overhead, collected on service cards.

Assume that the following amounts are shown:

Standard Allotment	Actual Expenses	Overhead Collected
\$100 000.	\$110 000.	\$112 000.

Such a statement would indicate that Standard Costs had not been realized, but on the other hand, $2 000 more overhead had been collected than had actually been spent, indicating that the burden percentages set up on the cost diagram were dependable. The $2 000 over collected, should be credited to an account called "Factory Adjustment Account."

The next month's statement might give the following figures:—

Standard Allotment	Actual Expenses	Overhead Collected
$100 000.	$108 000.	$107 000.

This would indicate that actual expenses had begun to take a downward course toward the Standard Allotment; but, on the other hand, $1 000 less overhead had been collected than had been actually spent. This $1 000 would be charged to "Factory Adjustment Account."

At the end of the year, if the "Factory Adjustment Account" showed a net credit of, say, $2 000, this amount would be credited to Surplus Account. On the other hand, if "Factory Adjustment" shows a net debit of $2 000, then this amount should be charged to Surplus Account and Factory Adjustment Account closed.

The Surplus Account thus serves exactly the purpose of a fly-wheel, as it is a reservoir of business energy, in which excess revenue is stored during good times, and from which it can be withdrawn to meet the demands of the business in dull times, when revenues fall below operating costs.

377. However, in order that a fly-wheel may perform its function satisfactorily, it must be supple-

mented by an automatic governor; and this business lacks.

The mean line of Figure 9 is not horizontal, but follows a somewhat irregular course, according to the average economic state of the world. Ordinarily it tends gradually upward, because of the gradual general increase of wealth; but when there is a general destruction of wealth, such as is occurring now, it drops to a lower level, from which it again tends slowly upwards, as wealth is again accumulated.

378. Where there is no governor which automatically adjusts output to such fluctuations of demand, the only resource is control by human intelligence; and in order that the business management may exercise this, it is necessary that it should be supplied with correct and adequate information, not only as to the average condition covered by the last complete cycle, from A to C, but also with reference to the fluctuation occurring at the moment.

In the first place, due to the gradual upward tendency of the Mean Line of Figure 9, no cost diagram would be permanently useful, even if business should never depart from normal. A Cost Diagram should therefore be made ordinarily at least once a year, taking on the last annual period and dropping off some period in the past, according to judgment; but in case departments are rearranged and accordingly use altered amounts of floor space or labor, or in case there are any other great changes in buildings, equipment or methods, it would be necessary to prepare a new diagram as often as such changes occur.

379. In cost finding for the purpose of laying out a campaign of efficiency work, the Ideal must evidently be to ascertain costs as they actually are at the time

such a campaign is begun; and for this reason the accounts on which a diagram for this purpose is based, should evidently not go further into the past than is necessary to cover the seasonal fluctuations to which the business is regularly subject in normal times; and for special reasons it may be desirable that they should cover even less time. For example, though this is written less than one year after the outbreak of the war, it is evident that that event produced a drop in the Mean Line of the Figure 9 similar to that from *C* to *D*, and that burden ratios based on the condition of business prior to *C*, would in most cases be far from those actually existing now.

In order to achieve the Ideals of the sales manager and the general manager, as they are stated at the beginning of this chapter, it is necessary that they should know, not only the average condition of the business, but also as nearly its momentary condition as possible. It is therefore necessary that they should be supplied with costs figured not only by burden ratios derived from a complete business cycle from *A* to *C*, but also from the period from *D* to the present, and perhaps from even a shorter period of the most recent past.

The last case occurs, for example, in the confectionery business. The principal raw materials, flour and corn syrup, are continually fluctuating in price on the market, and the demand for the product is seasonal. It is therefore necessary for the management to know at all times how cost of the product is affected by variation in the price of either of these materials and by storage for any period of time before sale. The means that have been adopted in some cases to accomplish this have been the determination of standard

costs of flour and of corn syrup and of standard burden ratios from the complete business cycle just past, and supplementing these by tables showing the effect on costs, of variations by fractions of a cent in the prices of flour and corn syrup, and of varying periods of storage. This information enables the management to judge, for example, whether a low price of raw materials in February would justify laying in a large stock of them, if the sale of the finished product is not expected before the Christmas demand comes on.

Chapter XVII

ESTIMATING FINANCIAL RESULTS

380.

GANTT relates the following incident:— "A man found that his cost on a certain article was 30 cents. When he found that he could buy it for 26 cents, he gave orders to stop manufacturing and to buy it, saying he did not understand how his competitor could sell at that price. He seemed to realize that there was a flaw somewhere but he could not locate it." Gantt continues the story thus:—

I then asked him what his expense consisted of. His reply was, labor 10 cents, material 8 cents and overhead 12 cents. My next question was: Are you running your factory at full capacity? and got the reply that he was running it at less than half its capacity, possibly one third. The next question was: What would be the overhead on this article if your factory were running full? The reply was that it would be about 5 cents; hence the cost would be only twenty-three cents.

The possibility that his competitor was running his factory full suggested itself at once as an explanation.

The next question that suggested itself was how the 12 cents overhead, which was charged to this article, would be paid if the article was bought. The obvious answer was that it would have to be distributed over the product still being made, and would thereby increase its cost. In such a case it would probably be found that some other article was costing more than it could be bought for; and if the same policy were pursued, the second article should be bought, which would cause the remaining product to bear a still higher expense rate.

If this policy were carried to its logical conclusion, the manufacturer would be buying everything before long and be obliged to give up manufacturing entirely.

Gantt's manufacturer made the common error of assuming that, if any direct expense were stopped, the overhead allocated to it would thereby be stopped also. This may result in some cases; but in so many cases it does not that, in estimating from our preliminary investigation the feasible economies, we must not make such an assumption, unless further investigation shows it to be correct.

381. In the main, overhead will remain constant regardless of increased production so that, if we can count on increasing production, we can also count on reducing in inverse ratio the overhead to be carried by every article.

With reference to some parts of the overhead, not even this is true. For example: of the power, the part due to driving shafting and belts will remain about constant regardless of production, but the rest will increase in approximately direct ratio to the production, and the effect of this increase on the load factor of the generating plant will also have a large influence upon the unit cost of power.

It is pointed out in Article 332 that increased cost of supervision must usually be assumed as a result of the betterment work itself, and that this must be allowed for in the estimate.

It was also pointed out in Article 329 that savings on labor must be shared with the workers, by paying them some form of efficiency reward, which for the purpose of the preliminary estimate might be assumed as 20 per cent of average time rates of the local labor market, for their respective classes of labor.

TABLE 15

Labor	AT ACTUAL PRODUCTION OF 871.5 UNITS				AT FEASIBLE PRODUCTION OF 1245 UNITS		
	Actual Cost per Year	Efficiency per Cent.	Standard Cost	Feasible Saving per Year	Cost at Present Efficiency	Standard Cost	Feasible Saving per Year
Direct:							
Department 1	$80 561	84.	$67 600	$12 961	$115 000	$96 500	$18 500
Department 2	54 406	81.5	44 400	10 006	77 900	63 200	14 700
Department 3	38 596	78.	30 000	8 596	55 100	42 900	12 200
Department 4	50 221	98.	49 300	921	71 800	70 200	1 600
Department 5	45 591	80.	36 600	8 991	65 200	52 300	12 900
Total direct labor	$269 375	84.5	$227 900	$41 475	$385 000	$325 100	$59 900
Materials Direct	$260 375	92.5	$241 387.50	$18 987.50	$371 450	$344 400	$27 050
Direct use of Equipment	63 180	95.	60 021	3 159	90 200	63 780	26 420
Maintenance	25 470	57.	14 500	10 970	36 400	20 750	15 650
Supervision	31 000	113.	37 500	6 500	44 300	37 500	6 800
Power (incl. of light and heat)	51 225	90.	46 102.50	5 122.50	66 592.50	50 000	16 592.50
Rent	121 225	92.	111 600	9 625	173 000	111 600	61 400
Miscellaneous	5 000	1000.	5 000		7 150	5 000	2 150
Total	$826 850		$744 011	$82 839	$1 174 092.50	$958 130	$215 962.50
Sales	$870 000		$870 000		$1 180 000	$1 180 000	
Profit and Cost of Selling	$43 150		$125 989		$59 075	$221 870	

382. Investigation having determined the approximate efficiencies and amounts of the various costs, the feasible saving results at once from the equation:—

$S = C\ (1. - E)$, in which
$C =$ cost,
$E =$ existing efficiency, and
$S =$ feasible saving.

The resulting estimate may be conveniently summarized in the form of Table 15.

383. The data of Table 15 are derived from the Cost Finding Diagram, Figure 7, as follows:—

TABLE 15 Cost of	FIGURE 7 From
Direct Materials	Third line, Block *MU*
Direct Labor, Total	Third line, Block *HW*
Direct Labor Distribution to Departments	Fifth line, Direct Departments
Direct Use of Equipment	Third line, Block *hE*
Power	Fourth line, Corrected Total
Supervision	Fourth line, Corrected Total
Maintenance	Fourth line, Corrected Total
Rent	Fourth line, Corrected Total
Miscellaneous	Fourth line, Corrected Total

384. Some explanation of the calculation of the table may be desirable.

For illustration, suppose the number of direct workers in the direct departments, 1 to 5, to be as follows:—

Department 1	120
Department 2	90
Department 3	70
Department 4	60
Department 5	75

Taking for example, Department 1; efficiency of use of direct labor determined as explained in Article 327 is 71.5 per cent. Efficiency of supply of direct labor,

determined according to Article 328, is 98 per cent. Referring to Article 329, the direct workers are paid on time rates equal to the market rate of wages. We must figure on paying them 20 per cent bonus at 100 per cent efficiency. Therefore efficiency of price of direct labor is 120 per cent. As recommended in Article 330, the preliminary estimate of the efficiency of distribution of labor is 100 per cent. Then the efficiency of direct labor is

$$.715 \times .98 \times 1.2 \times 1. = .84, \text{ or } 84 \text{ per cent.}$$

Since efficiency of supply is 98 per cent and efficiency of use is 71.5 per cent, the output from Department 1 is only $71.5 \times .98 = .7$ of what it would be if both these efficiencies were at 100 per cent.

The products of these two efficiencies in the several departments are as follows:—

Department 1,	70 per cent
Department 2,	68 per cent
Department 3,	65 per cent
Department 4,	82 per cent
Department 5,	67 per cent

Then weighting these products in proportion to the number of direct workers in the respective departments, the average value of the product is 70 per cent.

The accounts on which Table 15 is based are supposed to cover one year, during which time the 415 direct workers were employed for 1 245 000 man-hours, but their output was only that of $1\,245\,000 \times .7 = 871\,500$ standard man-hours. We may therefore call the actual output 871.5 units, and that of the same force at 100 per cent efficiency of supply and use 1245 units.

386. Then Department 1, having an actual direct

pay roll of \$80 561 at 84 per cent efficiency, at 100 per cent and no increase of production, would have [1]

$$\$80\,561 \times .84 = \$67\,600.$$

The feasible saving at 871.5 units of production is then \$80 561 — \$67 600 = \$12 961.

If the production is increased to 1245 units, at 84 per cent efficiency, the direct labor cost is increased in the same proportion, so that annual cost of direct labor =

$$80\,561 \times \frac{1245}{871.5} = \$115\,000,$$

in round numbers.

Similarly at 100 per cent efficiency and 1245 units of production annual cost of direct labor =

$$\$67\,600 \times \frac{1245}{871.5} = \$96\,500,$$

in round numbers.

The feasible saving at 1245 units of production is then \$115 000 — \$96 500 = \$18 500.

The figures for Departments 2, 3, 4, 5 and A are similarly calculated.

387. Direct Materials are represented as having an efficiency of 92.5 per cent. This does not mean that only 7.5 per cent of the original material goes into scrap. The figure of 92.5 per cent efficiency might be reached as follows:

---

[1] Wages = \$80 561 × .7 = \$56 392.70
Bonus = 56 392.70 × .2 = 11 274.54

Total direct pay roll = \$67 677.24

Present efficiency $= \dfrac{67\,677.24}{80\,561.} = 84$ per cent.

TABLE 16

	Per Year at Production of 871.5 units	
	Actual	Standard
Cost of materials worked into main product	$212 500	$212 500
Cost of materials worked into by-product	4 400	4 400
Scrap	72 000	32 800
Bonus to cutters of direct materials (See Article 302)		10 560
Cost of direct materials	$288 900	$260 260
Credit		
Amount realized annually by sale of scrap	$26 400	$16 747.50
Saving in coal by burning scrap under boilers	2 125	2 125
Total Credit	$28 525	$18 872.50
Cost of direct materials	288 900	260 260
Credit to direct materials	28 525	18 872.50
Net cost of direct materials	$260 375	$241 387.50
Efficiency of direct materials	92.5 per cent.	100 per cent.

	Per Year at Production of 1245 Units	
	At 92.5 per cent. Efficiency	Standard
Cost of materials worked into main product:		
$\$212\,500 \times \frac{1245}{871.5}$	$303 000	$303 000
Cost of materials worked into by-product:		
$\$4\,400 \times \frac{1245}{871.5}$	6 290	6 290
Scrap:		
$\$72\,000 \times \frac{1245}{871.5}$	103 000	
$\$32\,800 \times \frac{1245}{871.5}$		46 900
Bonus to cutters of direct materials		15 150
Cost of direct materials	$412 290	$371 340

Credit

Amount realized annually by sale of scrap:		
$\$26\,400 \times \dfrac{1245}{871.5}$	$37 800	
$\$16\,747.5 \times \dfrac{1245}{871.5}$		$23 900
Saving in coal by burning scrap under boilers....	3 040	3 040
Total credit..........................	$40 840	$26 940
Cost of direct materials......................	412 290	371 340
Net cost of direct materials.............	$371 450	$344 400

388. At a production of 871.5 units, the unit cost of direct use of equipment is $63 180 ÷ 871.5 = $72.50. At the same efficiency a production of 1245 units would cost $72.5 × 1245 = $90 200. The efficiency of this expense being 95 per cent, its annual amount at a production of 871.5 units is reducible to $63 180 × .95 = $60 021. In the hypothetical case of Table 15 it is supposed, to be on the safe side, that the increase of production from 871.5 to 1245 units will increase the depreciation to such an amount that the standard cost of direct use of equipment will rise to $63 780. Therefore, if efficiencies are raised to 100 per cent, and the entire improvement is used to increase production, the effect on the cost of direct use of equipment equals an annual saving of $90 200 — $63 780 = $26 420.

389. At a production of 871.5 units, the unit cost of maintenance is $25 470 ÷ 871.5 = $29.05. At the same efficiency, a production of 1245 units would cost $29.05 × 1245 = $36 400. The efficiency of maintenance being 57 per cent, the annual cost of maintenance at a production of 871.5 units is reducible to

$25 470 × .57 = $14 500.

It is supposed that the increase of production from 871.5 to 1245 units will involve an increase of the

standard cost of maintenance in the same proportion, making the annual standard cost at 1245 units, \$20 750. Therefore, if efficiencies are raised to 100 per cent, and the entire improvement is used to increase production, the effect on the cost of maintenance is equivalent to an annual saving of

$$\$36\,400 - \$20\,750 = \$15\,650.$$

390. \$6500 more of supervision per year is estimated as necessary to secure 100 per cent efficiency at either rate of production.

391. Since power includes light and heat, the annual cost of power at 1245 units of production and 100 per cent efficiency will only very slightly exceed that at 871.5 units and 100 per cent efficiency. To be safe it is estimated at \$50 000.

392. There is no reason why rent or miscellaneous expenses at 100 per cent efficiency should increase with production within the limits of Table 15.

393. An increase of production from 871.5 to 1245 units would increase sales to

$$\$870\,000 \times (1245 \div 871.5) = \$1\,243\,000,$$

if the larger output could be sold at the same unit price; but it is estimated that, in order to induce the market to absorb it, it will be necessary to reduce the selling price 5 per cent, so that the total annual sales at the larger production are only \$1 180 000. Some such allowance is usually necessary for a conservative estimate. In other words, beside the employer and the employee, there is a third party to all improvements, which we call the customer, the consumer, society, the State, or the government, according to circumstances. This party must be allowed a share in the benefits, and the Fair Deal therefore requires that it should also share in the burdens.

Chapter XVIII

SELECTION OF THE POINT OF ATTACK

394.

AS soon as Table 15 has been prepared, we are in position to select the place at which to begin work. The governing consideration is usually that the work must begin to pay for itself as soon as possible. And this generally leads to the selection of the best prospect for saving an appreciable sum of money in a short time.

395. Referring to Table 15, the efficiency of Maintenance is the lowest shown; and, the lower the efficiency, the easier it usually is to increase it. The estimated feasible saving, between \$10 970 and \$15 650 per year, is considerable; and an increase in the efficiency of maintenance would be likely to increase the efficiency of labor, of direct use of equipment, of power, and perhaps also of materials and supervision. Hence it is very likely that Maintenance would, *in this case,* be the best place to begin work. Whether or not this were the case, would depend very much on the difficulty of the measures necessary to increase the efficiency of maintenance and the time required to put them into effect.

396. Near the other extreme, the estimated feasible annual saving on rent varies from \$9 625 to \$61 400,

according to production; but the efficiency of rent is already 92 per cent, and, when the efficiency gets that high, it is harder and harder to get every additional per cent. Also the possibility of saving more than $9 600 on rent is dependent on increasing production, which is to be accomplished mostly through increase of the efficiency of labor.

Usually, other things being equal, the earlier the step in the process on which one can begin work, the easier the work is and the greater benefits the work produces elsewhere.

397. The question of Personnel has a very great and often a dominant influence in the selection of the point of attack. Referring to Article 383, Table 15: Department 1, coming at the beginning of the process and having an efficiency of labor of only 84 per cent, and an estimated feasible annual saving between $12 961 and $18 500, seems to offer a very good prospect for prompt results; but this may be completely nullified by the opposition of its foreman. If he does not co-operate in the work of betterment, still more if he opposes it, and the general management tolerates this attitude, one may be reduced to persuasion as a means of improving the efficiency of labor. By setting before a workman reasonable standards and offering him the prospect of increased earnings, if he makes good on them, it is possible to accomplish results *in time* by persuasion only, and against opposition; but the work goes very slowly under such conditions.

398. The great importance of the principle of Personnel may often make it desirable to begin with materials.

Another efficiency engineer told me of a plant in which merely starting an investigation of the efficiency

of materials in a certain department, led to an immediate threat of a strike. Considerable gold leaf was used in this department, and it was found later that the foreman was in the habit of stealing it and selling it to a junk dealer. He afterward bought back the gold leaf for the plant at a low price, and got great credit with the concern for buying gold leaf cheap. As soon as an investigation was started in his department, he induced the workmen to threaten a strike. Where any such graft is going on, attempts to work on materials are sure to meet strong opposition; but ordinarily no one about the plant has any objection to saving materials.

The workmen and minor executives upon whose skill and judgment the saving of materials depends, can often be paid a bonus on the economies which they effect. This affords an opportunity to demonstrate to the workers, at the outset, that the work is for their benefit as well as for that of the owners, and thus to secure their co-operation.

Materials come right at the beginning of the process, and have the determining effect upon other efficiencies due to that position. Faulty supply of materials may hold up manufacturing orders, throw planning and despatching into confusion, and cause serious money losses due to delays. Defective or improper materials may cause damage to machines and tools, loss of product well advanced in manufacture, faulty finished product, dissatisfaction of the customer, and loss of reputation and of business. For these reasons also they have strong claims to early attention.

One objection to starting with materials is that their efficiency is ordinarily high; but, if the annual bill for

materials is large, there may be a prospect of sufficient money saving to lead, in combination with the other reasons stated, to the selection of materials as the part upon which to begin work.

Certain features of the work on materials, for example the preparation of correct specifications and the installation of adequate inspection, may take considerable time and require considerable expense. These are objections to initial work on materials, but it is seldom that any line of work at any time can be brought to 100 per cent efficiency without intermediate work elsewhere.

399. In fact, just what is the beginning of the process depends upon the point of view. As to manufacturing processes, the first thing is raw materials; but, as to labor, it is employment; and, as to orders, it is planning. Hence, even after selecting a department in which to begin work, one would have at least three starting points from which to choose—the employment of its labor, the supply of its materials, and the planning of its work. One can readily imagine others. I have known a case in which tool-room service required first attention. Usually the line which offers the best prospect of appreciable money saving soon, is the one to follow first.

400. The manufacturing process seldom flows in an uninterrupted even stream from raw materials to finished product. There are eddies and back waters in it. An article may go to the final assembly department, and then come back to the first department for some operation. Thus, while the efficiency of departments early in the process strongly affects that of departments which come later, inefficiencies in the latter also disturb the efficiency of earlier ones.

401. For these reasons, whatever location or kind of work one may select for first attention, he is apt to find after a certain amount of work, that further progress there is unprofitable, until efficiencies have been brought up somewhere else.

Conversely, if one were to search for a starting point where he could make a locally finished job without creating any disturbance elsewhere, he would never begin at all. Neither can any fixed rule be given as to where to begin.

As in the old game of jack-straws, it depends on how the sticks fall out of the box. The only way to begin is to pick out the one that seems most promising and drag it out with the least possible disturbance of the rest of the pile.

This involves looking ahead to the results of one's work and preparing in advance to meet contingencies. This results in having at all times a tentative plan of work laid out ahead as far as it can be forecast with any reasonable approximation to the facts; but such a plan is necessarily only tentative, and one should always be ready to recast it in the light of unexpected events, or of fuller knowledge.

One therefore advances in efficiency work in a sort of spiral, getting all over the plant at every turn, and at every turn getting a little higher up in efficiency.

Naturally, also, one attacks the crudest and grossest inefficiencies first, and the removal of these clears the way for more refined measures; just as, in working materials, one first takes the heavy roughing cuts, then takes lighter cuts, and at last puts on the finish.

402. The selection of successive points of attack is the more important because the greatest possible concentration of attention on every such point is neces-

sary while work is being done upon it. The organization is accustomed to the old methods and will, at least, keep them going in some fashion; but a new method, no matter how superior it may be, goes awkwardly at first because of its unfamiliarity. Until the organization has become accustomed to the new, has mastered it, and is fully able to operate it, the efficiency force must give it very close attention. For these reasons, as in war, a mere holding force must be left where the situation is not critical, and the point selected for attack must be unitedly assaulted by all the remaining strength thus made available.

THE END

INDEX

In this Index the reference numbers given are those of the Articles, or numbered sections of the book, in which the subject described by the index title is discussed. This system, rather than that of indexing by page numbers, seems to provide the better and fuller guide to the reader; but it happens that throughout much of the volume Article and page numbers run closely parallel.

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